MANUAL OF NAVAL HYGIENE AND SANITATION

Volume I

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U.S. Bureau of Medicine and Surgery.

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BUREAU OF MEDICINE AND SURGERY
NAVY DEPARTMENT
WASHINGTON, D. C.

Foreword

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This volume has been prepared in order to maintain a source of ready information up to date and adapted to the needs of those responsible for safeguarding the health of the Navy. While it replaces the Manual of Naval Hygiene published in 1943, it is completely rewritten. Some material has been deleted and new matter has been added.

This manual is published with the hope that it will be a valuable addition to the libraries of medical officers concerned with preventive medicine and that it will also provide a comprehensive handbook for Medical Service Corps officers, hospital corpsmen and others who serve in situations precluding complete libraries.

C. A. SWANSON
Rear Admiral, Medical Corps
Surgeon General, United States Navy

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Chapter I

Messing Sanitation and Rations

Section I.--DUTIES AND RESPONSIBILITIES

1. Medical officers shall make inspections and recommendations to insure the quality and nutritional adequacy of rations served at authorized messes and the quality of foods and drinks served at ship's service stores and post exchanges.

2. Quality of Food

(a) A medical officer shall inspect, as to quality, all fresh food purchased for the general mess, and frequently inspect the fruit and other articles of food and drink offered for sale alongside. In localities where night soil is commonly used for fertilizing purposes, none of the vegetables ordinarily eaten uncooked shall be permitted on board; and no fresh milk, bottled waters, or fresh fruits of uncertain quality shall be allowed.

(b) Navy Regulations contains specific information of interest to every medical officer concerning responsibilities of the senior officers present, commanding officers and medical officers in maintaining the health and welfare of members of the naval establishment.

(c) Fresh food not previously passed upon by a United States Government inspector shall be inspected by a medical officer upon delivery; acceptance or rejection must be determined at once. Fresh food pronounced acceptable by a government inspector shall be inspected upon delivery.

(d) Bureau of Supplies and Accounts Manual makes the following reference to the medical officer's responsibilities. "The medical officer will inspect for quality all fresh provisions for the general mess, and will when re-

quired, inspect the provisions of the crew and report any that are unfit for use or likely to cause illness. He will report to the commanding officer any lack of care of cleanliness in the preparation of food for the crew which may be injurious to health and any lack of purity of cooking water or drinking water which is to be brought aboard. He will inspect weekly all provision storerooms and after each such inspection make to the commanding officer a written report of the sanitary condition in these spaces.

(e) The medical officer is responsible for passing on the edibility of food under conditions of known or suspected contamination with chemical warfare agents.

3. Balanced Rations.--The medical officer should request copies of weekly menus for the general mess and note from month to month whether a properly balanced ration is being prepared for the crew.

4. Fresh Milk

(a) The medical officer should make sure by routine examinations and inspections that fresh milk delivered under contract from day to day is fresh, clean, unadulterated, and uncontaminated.

(b) Only pasteurized fresh milk should be purchased. Unpasteurized fresh milk, even though it be of high grade and produced and handled under excellent sanitary conditions, is not free from danger of contamination with disease-producing micro-organisms. Milk not conforming essentially to Federal specifications shall be rejected.

(c) When milk is to be obtained from a source with which the medical officer is not familiar, he should ascertain if the milk is produced and marketed under adequate sanitary supervision by the local or state health department. If satisfactory control by governmental agencies be doubtful, the distributing plant should be visited to note whether modern methods and equipment are employed.

5. Meats

(a) Medical officers must be able to recognize meat and meat food products that are wholesome and desirable, from the standpoint of their condition, as food. Further, they must distinguish signs indicative of spoilage in kind and degree sufficient to justify condemnation of meat, poultry, fish, etc., as unfit for human consumption. All meat of questionable quality should be recommended for destruction. When only a portion of a quarter is of doubtful quality, that portion should be removed and the remainder saved if practicable.

(b) All deliveries of meat and meat food products made to Naval or Marine Corps activities in the continental United

States must bear the inspection stamp of the United States Department of Agriculture "U. S. Inspected and Passed," as well as the inspection stamp of the USN or USMC, or U. S. Army VC. Medical officers shall inspect all meat for quality (condition) at the time of delivery.

6. Cleanliness of Mess Gear and Utensils.

(a) Medical officers shall inspect all cooking and messing facilities for cleanliness and shall make any necessary reports and recommendations to the commanding officer.

(b) Cooking utensils should be washed thoroughly with hot water and soap or other cleansing agent after use and after application of mechanical or chemical polishing agents. Mess gear should, after each use, be washed sufficiently to remove adherent particles of food and mouth secretions, sterilized, and allowed to dry without wiping. The minimum safe sterilization requirement is submersion in, or equivalent exposure to, water at a temperature above 180° F. for not less than 20 seconds.

7. Cleanliness and Health of Food Handlers.--Ships cooks, bakers, stewards, steward's mates, messmen, butchers, and helpers must be required to keep their hands scrupulously clean. Sufficiently close supervision should be maintained over the health of food handlers to insure prompt detection of respiratory infections, superficial pustular lesions and communicable disease.

8. Civilian Restaurants frequented by Naval Personnel. Eating and drinking places, frequented by naval personnel, not fulfilling the sanitation requirements of the Navy and those of Grade A restaurants as determined by the Public Health Service Code regulating eating establishments may be placed out of bounds to naval personnel. The compliance with sanitation requirements of such establishments is best determined by inspections in conjunction with the local health authorities.

Section II.--MESS MANAGEMENT

9. Any station reflects the interest of its commanding officer in the commissary and mess. Although a commanding officer may delegate direct supervision of a mess, the responsibility for proper management remains his. This is especially true in smaller stations in which it is difficult to obtain adequate galley equipment, and administrative help is needed to get it. The interest of the commanding officer leads to a better performance of cooks and bakers because they feel their work is

regarded as important. Inspection and sampling of prepared products by the commanding officer or inspection parties leads to high morale in the galley.

10. Medical officers are often the only ones at a station with a background in biological science, thus they can render a real service by taking greater interest in food preparation and nutrition.

11. Poor cookery is usually found in galleys where the Navy Cook Book is not followed. Many galleys maintain sheets for recording cooking time, if accurately kept they are a valuable aid and enhance the finished product.

12. The production of well-prepared food depends in part upon the availability and interest of personnel. The ratio of mess cooks varies, the average is about one to twenty. Instruction and supervision must be constant until they are acquainted with all aspects of food and food handling, etc.

13. Common objections found in messes are:

(a) Sufficient milk is not available.

(b) Mutton and cold cuts are served too frequently.

(c) Beans and hash served for breakfast, instead of such items as hotcakes, eggs, doughnuts, etc.

(d) Insufficient innovations in the type of bread products

(e) Disregard for color combinations that can be produced in the combinations of salads and vegetables.

14. Good food is produced when:

(a) Interested full-time commissary officers and chiefs or chefs are in charge, and an adequate complement maintained.

(b) Galleys are well equipped and kept in good repair.

(c) Selection of food stuffs is wide and varied.

(d) Laundry service is adequate.

(e) Garbage disposal is adequate.

(f) Surroundings are well kept.

Section III.--THE FUNDAMENTALS OF MESSING SANITATION

15. Objectives.--Messing sanitation consists essentially of cleanliness throughout the entire preparation and serving of food, and its protection at all times against all sources of contamination. The maintenance of desired sanitation depends upon:

(a) The adequacy, location, and sanitation of the facilities.

(b) The selection, indoctrination, and supervision of food handler personnel.

(c) The wholesomeness of the food as received and issued, and its protection against contamination during preparation and serving.

(d) Keeping the length of time between the preparation and serving of food at a safe minimum.

(e) The washing, sterilization, and storage of mess gear and utensils.

(f) Routine sanitary inspection, followed by reports and recommendations to the commanding officer.

(g) Sanitary orders for the mess.

(h) Adequate and well maintenance refrigeration spaces.

16. Facilities.--

(a) Definition: The term "messing facilities" includes the galley, bake shop, butcher shop, mess hall, food storage and refrigeration spaces, and scullery. Those sections of ship's service stores and post exchanges which deal in food and drinks are to be considered as part of the messing facilities.

(b) Location: The location of messing facilities should:

(1) Have good natural drainage and not be subject to flooding.

(2) Be conveniently near to living quarters.

(3) Be to the windward of and at least 100 yards from all latrines.

(4) Be as far removed as possible from areas favorable to fly and mosquito breeding.

(5) Be to the windward of and as far as possible from all sources of obnoxious odors.

(6) Be as free as possible from dust.

(7) Be partially shaded.

(8) Be near a source of potable water.

(c) Construction: Concrete decks properly sloped for drainage, with adequate outlet connections to the sewerage system, should be provided for galley and food storage spaces. Construction should be designed to exclude rodents permanently and limit their places of shelter and harborage. (See Chapter XII, Rodent Control).

(d) Fly Control: All messing facilities should be thoroughly and effectively screened throughout in areas where flies or mosquitoes are present. If wire screening is not immediately available, cotton netting should be used as a temporary substitute. Residue spraying of DDT has proved invaluable in the control of flies in and about messing facilities. The techniques of fly control are discussed in Chapter IX, Properties and Uses of DDT, and Insect Control.

(e) Sanitary Maintenance: The entire physical plant of the messing facilities and their environs should be maintained in a scrupulously clean condition at all times. Rodent and vermin-proof containers provided with tight covers shall be

used to dispose of all garbage and refuse, and to dispose of any other material inducive to the harborage and multiplication of, or the serving as sources of attraction or as food for rodents, vermin, and insects. All liquid wastes should be promptly disposed of in an approved sanitary manner. (See Chapter VII, Waste Disposal). No trash piles or any accumulation of rubbish that provides harborage and shelter for rodents shall be permitted within the camp area.

17. Food Handler Personnel.

(a) Definition: The term "food handler" shall include all individuals, service personnel, civilians or natives employed in any of the Navy messing facilities.

(b) Physical Examination: All food handlers shall be free from communicable disease, pustular lesions of exposed surfaces, and either symptoms or carrier status of enteric diseases and respiratory infections before they are assigned to such duty. The medical officer shall determine compliance with this by thorough physical examinations supplemented by the laboratory examinations when indicated and review of the health record for past history of the aforementioned condition. A weekly "surprise" inspection of all food handlers for personal hygiene shall be conducted by the medical officer. Laboratory examinations will be conducted when deemed necessary.

(c) Health Supervision: The supervision of the health of food handlers by the medical department shall be sufficiently close to insure the early detection of communicable diseases and pustular lesions of the exposed parts. Food handlers found with either should be excluded from further duty in the mess until pronounced satisfactory for resumption of duties by the medical officer. To safeguard against the carrier status which follow certain enteric diseases and respiratory infections, caution must be exercised in permitting potential carriers to return to food handling duties. In the absence of laboratory facilities for stool examinations, the following periods of time after complete clinical recovery from certain enteric diseases are recommended: bacillary dysentery, one month; salmonella infections, two weeks. Amebic dysentery requires laboratory proof of cure. Complete clinical recovery is considered a safe and practical guide for most communicable diseases.

(d) Indoctrination: All food handlers should be thoroughly indoctrinated in personal hygiene and messing sanitation and in both the methods of and the importance of preventing food-borne infections and intoxications. Food handlers should be familiar with paragraphs 41460 to 41476, Bureau of Supplies

and Accounts Manual. Commissary personnel should be indoctrinated in training camps or staging areas. Temporary food handlers should be indoctrinated as they are assigned to duty. Audio-visual aids, where available, will expedite this training program.

(e) Personal Hygiene and Cleanliness: All food handlers shall be bodily clean and wear clean garments when working in the mess. Where native help is employed in the galley, it may be necessary to provide clean outer garments, wash room, shower, and toilet facilities. Commissary personnel shall keep their nails trimmed short, and special attention shall be directed to the cleanliness of their hands. They shall visit the sick bay immediately on noticing any open lesions on the face, neck, arms and hands. To insure compliance with foregoing the master-at-arms of the galley or responsible petty officers of the watch should be designated to inspect each watch or section. (Sick call hours will not be regarded). It is desirable that caps be worn at work to prevent hair from falling in food being prepared. Ample and convenient hand-washing facilities shall be provided including hot and cold running water, soap, and sanitary towels. Utensil-washing vats shall not be used as handwashing or laundry facilities for personnel. Personnel shall be instructed frequently to wash their hands with soap and water after each visit to the head. Conspicuous signs to this effect shall be posted in the various messing facilities. A guide to other precautions in personel hygiene and cleanliness recommended by the Public Health Service may be found in Ordinance and Code Regulating Eating and Drinking Establishments, Public Health Bulletin No. 280, 1943 edition.

18. Cooking of Foods.--Cooking plays a major role in reduction of disease dissemination. Adequate, thorough cooking of foods, particularly pork, is of sanitary significance since bacteria and other organisms are destroyed. Care must be taken to stir large masses of food such as spaghetti thoroughly so that cooking will be complete to the center of the mass. Sausage, hams, and other pork products must be heated sufficiently to attain a temperature of 137° F. in the deepest portions if trichinosis and food poisoning outbreaks are to be prevented.

19. Disinfection or "Sterilization" of Mess Gear.

(a) No simply performed test has been devised to determine the effectiveness of any type of apparatus for sterilizing mess gear. Proper design, adequate capacity, and correct operation must be insisted upon to achieve disinfection. Where facilities are available for making bacterial counts of mess

gear, utensils yielding standard swab counts of more than 100 bacteria may be considered improperly washed.

(b) Dishwashing machines should be so designed that a forceful stream of water will reach all surfaces of the gear when it is properly racked. The construction should be such that the washing and rinsing spray jets are readily accessible for inspection and cleaning. Both the wash water and the rinse water tanks should be equipped with thermometers so placed that the operators and inspectors can readily check upon the temperatures. The mechanical part for moving the racks through the machine should be of such design that it can be regulated to give proper exposure to wash and rinse sprays. If thermostatically controlled, the thermostat for the rinse water tanks should be set for 180° F. BuShips Circular letter directs the installation of thermostatic control equipment on all dishwashing machines. (ND-Bull 46-1810).

(c) A dishwashing machine of proper design should be operated in accordance with the following directions:

(1) For each 25 gallons of water in the wash water tank, one pound or two mess cupfuls of detergent compound should be added at the beginning of operations. In order to keep the concentration of the detergent at an efficient level, one-half of this amount should be added at the end of each 20 minutes of operation. The wash water should be changed often enough to be kept reasonably clean.

(2) All mess gear should be thoroughly scraped and wherever practicable prerinsed before being put into the machine.

(3) All gear should be properly racked to insure exposure of all parts to the sprays and to insure drainage.

(4) The temperature of the wash water should be not less than 120° F. and not more than 140° F. Fats will not emulsify properly below 120° F. and proteins will "cook" onto the gear above 140° F.

(5) The exposure time in the wash water compartment will depend upon compliance with the above factors. Ordinarily 30 to 40 seconds are required, but proper scraping and prerinsing may allow for shorter exposures. The state of cleanliness of the gear is the determining factor.

(6) The temperature of the rinse spray should be not less than 180° F. The exposure time should not be less than 20 seconds.

(7) The dishes should be allowed to dry in the racks and then be stored in a clean compartment protected from insects, dust, and other contamination.

(8) Dishwashing machine must be kept clean at all times and thoroughly cleansed at night ready for use the next morning.

(9) Dish trucks should be cleaned before securing.

(10) Charts depicting proper procedures for operation in a maintenance of dishwashing machines and other scullery equipment are available from manufactures and should be conveniently posted in every scullery.

(d) In the field with improvised devices, it is more practical and safer to employ actively (visibly) boiling water throughout the process or at least for the rinsing portion of the process. This necessitates apparatus for keeping the water boiling and for immersing and agitating the utensils (for 30 seconds), particularly for the rinsing part of the process. Usually three waters are provided for cleaning and sterilizing mess gear in the field. A rich soapy wash at about 120 to 140 degrees Fahrenheit (as hot as the hands can stand), for removing food with the help of brushes or mops is the first step. The water is skimmed frequently and refreshed after every 200 mess kits. The second water consists of a slightly soapy rinse at boiling temperature to remove scum and grease. This water is skimmed frequently also. The third water is a clear boiling rinse for sterilizing by immersion of the mess gear for at least 30 seconds.

(e) It is obvious that strict supervision is necessary with any and all methods of cleaning and disinfecting mess gear. The mess gear should be allowed to dry of its own heat and stored in as sanitary manner as possible. In all cases, except where the medical officer directs otherwise, the mess gear should also be immersed in boiling water for one-half minute immediately before meals.

(f) Compounds for dishwashing and cleaning of galley and other mess equipment; the following cleaning materials are recommended for use as indicated.

(1) Mechanical Dishwashing - Dishwashing compound: Catalog of Navy Material, Stock Number 51C-1516-100, in 100-lb. drums. Spec. N:51-c-49

(2) Hand Dishwashing: (a) Laundry Powdered Soap: Catalog of Navy Material, Stock Number 51-S-1735, in 100-lb. drum Spec. P-S-596. For washing with fresh water only. (b) Salt Water Soap (Bar): Catalog of Navy Material, Stock Number 51-S-1785,25 bars (75 lbs.) to a box; Spec. N:51-S-46. For washing with sea or fresh water. (c) Grit Soap, Type A: Catalog of Navy Material, Stock Number 51-S-1530 in 10-ounce cake, Spec. N:51-S-20. For light

scouring of glassware, chinaware, and enamelware. (d) Grit Soap, Type B: Catalog of Navy Material Stock Number 51-S-1550 in 9-ounce cake, Spec. N:51-S-20. For rough work, scouring and scrubbing.

(g) Chemical sterilization may be resorted to when the use of heat is impractical. In order that a chemical agent (chlorine) may be effective, the dishes or utensils must be thoroughly clean and free of organic matter and must be completely exposed for at least two minutes to a solution of proper concentration (chlorine residual 50 to 100 ppm, which could be produced by 1 ounce of full strength high test calcium hypochlorite to 50 gal. of water or 1 ounce of 5 per cent sodium hypochlorite solution to 4 gal. of water). The gear may be rinsed with clean potable water after exposure to chlorine, if desired. The chlorine concentration can be determined by a simple test using ortho-tolidine. Silver and plated tableware should not be treated with chlorine because of the discoloration imparted by silver chlorides. A number of brands of quarternary ammonium compounds (Cationic disinfectants) are preferred if used according to directions on the label where cold sterilization is necessary. (See Ch. XI Sec. IV) Order as:

51-D-394-55 Germicide and fungicide-- 1 gal. 5x standard strength------------- Gal.
51-D-394-60 Germicide and fungicide - 1 gal. 10x standard strength------------ Gal.
51-D-394-62 Germicide and fungicide-- 5 gal. carboy. 10x standard strength---- Gal.
51-D-394-66 Germicide and fungicide-- 5 gal. carboy. 30x standard strength---- Gal.

20. Care of Mess Gear and Utensils.

(a) Silverware is inspected daily and cleaned and polished at least once a week. Forks with broken tines should be surveyed immediately. Badly worn, rough edged spoons, cracked cups, dishes and other chinaware shall be surveyed. The cracks form a harbor for food and bacteria. Pitchers are scoured weekly with cleansing and polishing soap then run through the washing machine.

(b) Galley utensils.

(1) Coppers, steam-jacketed kettles and urns are cleansed with a scrub brush and rinsed with hot water. The exhaust flange which is subject to an accumulation of grease must be kept clean.

(2) Meat and vegetable grinders, peelers, slicers, and chopping machines are taken apart after each use. Each part is cleansed in hot soapy water, with a brush if nec-

essary, followed by immersion in boiling water, dried, and reassembled.

(3) All other galley equipment is kept scrupulously clean at all times with vigorous brush scrubbing and hot soapy water followed by a hot water rinse (about 180 °F.)

(4) Meat blocks: It is unwise to wash the cutting surface of the meat block because moisture softens and expands the wood and weakens the glued joints. With such treatment the block soon becomes insanitary as a result of the wood becoming saturated with water, blood, and meat juices. Salting has not been shown to be bactericidal and may interfere with drying or conceal an unclean surface. Seven rules to follow in keeping the cutting surface of the meat block in good condition are: (a) Use steel scraper and wire brush to clean cutting surface: (b) Keep cutting head of block dry; (c) Clean top of block after each use; (d) Use entire cutting surface as much as possible; (e) Maintain same bevel on edges of block that it had when new; (f) Turn block regularly so cutting surface will wear down evenly; (g) Plywood covers (water-proof-bonded, three-fourths inch thick or over) are recommended for use on meat blocks. These are easily washed, sterilized, dried, and can be readily replaced when worn out.

(5) Ranges are thoroughly cleansed once a week in addition to usual daily cleaning of inside of oven, the unit cover, drip pans, and range grease receptacle.

21. Undesirable metallic coatings on food and beverage containers for preparation and storage.

(a) Zinc and copper coatings react with small amounts of acid in foods to produce salts. Zinc and copper salts may cause gastro-enteritis. Copper salts destroy vitamin C. Lemonade, etc., made or stored in galvanized iron cans has caused severe nausea, vomiting, and diarrhea. Symptoms appear in 10 to 15 minutes.

(b) Antimony enamel chips readily. The antimony introduced into food by this method may cause gastro-enteritis.

(c) Porcelain-enamelled ware and chrome platings over cyanide-hardened steel crack easily. The cracks harbor food allowing the multiplication of bacteria.

(d) The use of food containers repaired or lined with cadmium is strictly forbidden. Food poisoning from acid food and beverages stored in cadmium-plated vessels is not infrequent. Symptoms develop in 10 to 15 minutes if poisoning is severe. A simple chemical test to detect cadmium was

described in the U. S. Naval Medical Bulletin, Vol, 43, No 2, page 398, August 1944.

(e) Lead poisoning has been reported from drinking carbonated water beverages. Certain manufacturers of beverage syrups have provided for the installation of carbonated beverage machinery aboard U. S. naval vessels. Investigation of a number of such installations has revealed that samples of carbonated water contain soluble lead compounds varying from 0.5 ppm to 4.0 ppm. The maximum lead content in potable water should not exceed 0.1 ppm. Sources of contamination have been established to be the luting or joint, thread, and connection sealing compounds employed in the assembly and installation of the machinery. Lead compounds insoluble in water may become appreciably soluble in acid solutions. Where tests indicate contamination in excess of allowable standards, all joints and connections in machinery and accessory parts of the installation shall be disassembled. All traces of the luting or sealing compound shall be cautiously and thoroughly removed from the affected parts followed by swabbing with weak acid solution and flushing with water. The reassembly of the machinery may be effected with the aid of non-toxic luting or sealing compounds and additional samples shall be tested for lead content.

Section IV.--FOOD INSPECTION

22. Meats.

(a) Within the continental limits of the U. S., all meats and meat food products delivered to naval or Marine Corps activities must have met the rigid requirements of wholesomeness and grade established by the specification under which the produce was procured. The "U. S. Inspected and Passed" stamp of the U. S. Department of Agriculture, which must appear on the meat or the original package containing it, attests to the fact that the meat has been processed from a healthy animal under sanitary conditions. Appearance of the USN, or USMC, or U. S. Army VC inspection stamps on the meat or package containing it is a further requirement. Any one of these latter stamps indicates that the product and the method of processing it are in accordance with the specification.

(1) The wholesomeness of the meat is dependent upon conditions of storage and transit, since considerable time may elapse between the date of the foregoing inspections and date of delivery to the consuming activity. The in-

spection of meat for quality (condition) by the medical officer at time of delivery should, therefore, be made with the view of determining desirability of the produce as food.

(2) Meat carcasses and cuts may be delivered "fresh chilled" or "frozen." Fresh, chilled products include those fresh meat items which have been held at temperatures just above freezing. They are chilled but are not, and have not been, frozen. The lean of frozen meat is usually considerably darker in color than fresh chilled meat of the same grade.

(3) Carcasses and cuts of meat are assigned to classes and grades indicating their probable palatability (flavor and tenderness). Classes refer to the size and age of the carcass. Grades refer to the shape or "build" of the carcass or cut (known as conformation), the amount and distribution of fat (known as finish) and the color, texture, and firmness of the lean and the character of the fat and bone (known as quality).

(4) Fresh chilled meat that is not discolored, that is firm and elastic to the touch, reasonably dry, and free from slime or slimy deposits and abnormal odors may generally be considered to be sound and wholesome. Undesirable characteristics to look for when inspecting fresh chilled meat are: (1) Extensively moist, sticky or slimy surface; (2) Extreme discoloration; (3) Abnormal odors; and (4) Presence of edema or emphysema. Skewers thrust into the depths of cuts near joints or bone should have no unpleasant odor when withdrawn.

(5) Inspection of frozen meat items should be made with a view to determining whether or not conditions of storage and transit have been such as to maintain these items in frozen condition at all times. Alternate freezing and thawing of frozen meat items is objectionable and reduces the storage life of the meat.

(6) When inspecting cured and smoked meats - hams and bacon particularly, it should be recognized that rather extensive surface mold can be present without rendering the product unfit for food. In most cases where this condition has been allowed to develop on hams and bacon the product can generally be "overhauled" in such a way that it is made wholesome and fit for preparation as food.

(b) Prevention of trichinosis:

(1) The prevention of trichinosis requires that pork shall be effectively heated or refrigerated to destroy live

trichinae. Destruction by heating is accomplished at a temperature not lower than 137° F. It is important that each piece of sausage, ham, or other pork product be heated throughout to or above the required temperature. Temperatures that destroy trichinae by refrigeration are variable depending upon thickness of the meat and exposure periods.

(2) The following directions for refrigerating are quoted from War Food Administration Meat Inspection Regulations of March 24, 1945.

At any stage of preparation and after preparatory chilling to a temperature of not above 40° F. or preparatory freezing, all parts of the muscle tissue of pork or product containing such tissue shall be subject continuously to a temperature notthigher than one of those specified in Table 1-1, the duration of such refrigeration at the specified temperature being dependent on the thickness of the meat or inside dimensions of the containers.

TABLE 1-1--REQUIRED PERIOD OF FREEZING AT TEMPERATURES INDICATED

Temperature ° F.	Group 1	Group 2
	Days	Days
5	20	30
-10	10	20
-20	6	12

Group 1 comprises product in separate pieces not exceeding 6 inches in thickness or arranged on separate racks with the layers not exceeding 6 inches in depth, or stored in crates or open boxes not exceeding 6 inches in depth, or stored as solidly frozen blocks not exceeding 6 inches in thickness.

Group 2 comprises products in pieces, layers or within open containers the thickness of which exceeds 6 inches but not 27 inches, and product in closed containers including tierces, barrels, kegs, and cartons having a thickness not exceeding 27 inches.

The product undergoing such refrigeration or the containers thereof shall be so spaced while in the freezer as will insure a free circulation of air between the pieces of meat, layers, blocks, boxes, barrels, and tierces in order that the temperature of the meat throughout will be promptly reduced to not higher than 5° F., -10° F., or -20° F., as the case may be.

23. Poultry.--Frozen and fresh poultry should be firm and elastic to the touch, and free from slimy deposits and discolorations, and abnormal odors.

24. Fish.

(a) Fresh-caught: The characteristics of sound fresh fish are red gills, bright bulging eyes, closed mouth, firm flesh, and glittering, firmly adherent scales free from slime, and the body is solid, does not easily bend and sinks in water. Stale fish have pale gills, dull sunken eyes, open or easily opened mouth, soft easily pitted flesh, and the body bends easily and floats on water.

(b) Thawed out fish: At times frozen fish are thawed out and offered for sale as fresh-caught fish. They may be detected by their pale gills, dull eyes, soft flesh and dark blood.

(c) Shellfish, crabs, and oysters should not be accepted unless they are alive. Shucked oysters and clams should not be permitted to come in direct contact with ice. Frozen oysters are satisfactory only if kept continuously frozen.

25. Canned Food.

(a) All canned goods should be examined carefully for evidence of defective containers. Such evidence is manifested by marked denting or rusting, leaking, loss of the normal concavity of one or both ends of the can, or by actual bulging of one or both ends of the can.

(b) Serious denting may permit leakage or contamination. If an end of the can is concave showing the continued presence of the vacuum, the can may be safely used, provided the odor and appearance of the contents are normal. The same general rule may be applied to rusting.

(c) All cans showing any bulging should be destroyed.

(d) The loss of the normal concavity of the ends of cans signifies improper canning or the formation of a small amount of gas or a small leak and should be cause for rejection.

Section V.--SANITARY CONTROL OF DAIRY PRODUCTS

26. Fresh Milk.

(a) Navy Department Standards. Pasteurized fresh milk complying with Federal Specifications, Type II (pasteurized fresh) will be procured for naval and Marine forces where available.

(1) Specifications common to all grades, Type II, are: (a) Solid content. Total solids, 11.25% or more; solids not fat, 8.0% or more; butter fat, 3.25% or more. (b) Pasteurization: Complete pasteurization by either the vat method, at not less than 143° F. for not less than 30 minutes, or the flash method at not less than 160° F. for

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not less than 15 seconds. (c) Cooling: Immediately after pasteurization the milk should be cooled to a temperature below 50 ° F. and kept at such temperature until delivery. (d) Delivery: All milk shall be delivered at a temperature not higher than 50° F. within 24 hours of pasteurization. (e) Containers: All milk shall be in containers which are filled and capped by approved mechanical equipment and unless otherwise specified the cap or cover shall protect the pouring lip to at least its largest diameter. (f) Sanitary Supervision: All milk shall be from herds certified to be free from tuberculosis, and shall be produced, pasteurized, packaged and distributed in a sanitary manner.

(2) Specifications which vary according to Grade No. are: (a) Type II, No. 1.--This refers to Grade A pasteurized milk produced in a locality which has formally adopted the Public Health Service Milk Ordinance and Code. The logarithmic average of at least the last four consecutive bacterial counts shall not exceed 200,000 per ml. prior to pasteurization, nor 30,000 per ml. after pasteurization. (b) Type II, No. 2.--This is the first quality, except certified, pasteurized milk produced in a locality which has not formally adopted the Public Health Service Milk Ordinance and Code, but requires a milk better than Type II, No. 3. Ordinarily the bacteriological requirements are the same as No. 1. (c) Type II, No. 3.--This refers to Grade B pasteurized milk produced in a locality which has formally adopted the Public Health Service Milk Ordinance and Code. The logarithmic average of at least the last four bacterial counts should not exceed 1,000,000 per ml. prior to pasteurization nor 50,000 per ml. after pasteurization.

(b) Sampling, Inspections, Examinations, and Appraisal of Milk.

(1) Frequency of Sampling; The frequency of sampling and testing will depend upon the level of sanitary practices employed in the production, processing, and distribution of the milk supply, the quality of the existing sanitary supervision, and the past record of the particular pasteurization plant. Where laboratory facilities are available at naval activities, routine bacteriological examinations and phosphatase tests shall be made at the discretion of the medical officer. In no case should bacteriological counts be made less often than once a week.

Table 1-2.--Table to be used in computing logarithmic averages of bacterial counts

Counts	Logarithms	Counts	Logarithms	Counts	Logarithms	Counts	Logarithms	Counts	Logarithms
1, 000	3. 00	61, 000	4. 79	310, 000	5. 49	910, 000	5. 96	6, 100, 000	6. 79
2, 000	3. 30	62, 000	4. 79	320, 000	5. 51	920, 000	5. 96	6, 200, 000	6. 79
3, 000	3. 48	63, 000	4. 80	330, 000	5. 52	930, 000	5. 97	6, 300, 000	6. 80
4, 000	3. 60	64, 000	4. 81	340, 000	5. 53	940, 000	5. 97	6, 400, 000	6. 81
5, 000	3. 70	65, 000	4. 81	350, 000	5. 54	950, 000	5. 98	6, 500, 000	6. 81
6, 000	3. 78	66, 000	4. 82	360, 000	5. 56	960, 000	5. 98	6, 600, 000	6. 82
7, 000	3. 85	67, 000	4. 83	370, 000	5. 57	970, 000	5. 99	6, 700, 000	6. 83
8, 000	3. 90	68, 000	4. 83	380, 000	5. 58	980, 000	5. 99	6, 800, 000	6. 83
9, 000	3. 95	69, 000	4. 84	390, 000	5. 59	990, 000	5. 99	6, 900, 000	6. 84
10, 000	4. 00	70, 000	4. 85	400, 000	5. 60	1, 000, 000	6. 00	7, 000, 000	6. 85
11, 000	4. 04	71, 000	4. 85	410, 000	5. 61	1, 100, 000	6. 04	7, 100, 000	6. 85
12, 000	4. 08	72, 000	4. 86	420, 000	5. 62	1, 200, 000	6. 08	7, 200, 000	6. 86
13, 000	4. 11	73, 000	4. 86	430, 000	5. 63	1, 300, 000	6. 11	7, 300, 000	6. 86
14, 000	4. 15	74, 000	4. 87	440, 000	5. 64	1, 400, 000	6. 15	7, 400, 000	6. 87
15, 000	4. 18	75, 000	4. 88	450, 000	5. 65	1, 500, 000	6. 18	7, 500, 000	6. 88
16, 000	4. 20	76, 000	4. 88	460, 000	5. 66	1, 600, 000	6. 20	7, 600, 000	6. 88
17, 000	4. 23	77, 000	4. 89	470, 000	5. 67	1, 700, 000	6. 23	7, 700, 000	6. 89
18, 000	4. 26	78, 000	4. 89	480, 000	5. 68	1, 800, 000	6. 26	7, 800, 000	6. 89
19, 000	4. 28	79, 000	4. 90	490, 000	5. 69	1, 900, 000	6. 28	7, 900, 000	6. 90
20, 000	4. 30	80, 000	4. 90	500, 000	5. 70	2, 000, 000	6. 30	8, 000, 000	6. 90
21, 000	4. 32	81, 000	4. 91	510, 000	5. 71	2, 100, 000	6. 32	8, 100, 000	6. 91
22, 000	4. 34	82, 000	4. 91	520, 000	5. 72	2, 200, 000	6. 34	8, 200, 000	6. 91
23, 000	4. 36	83, 000	4. 92	530, 000	5. 72	2, 300, 000	6. 36	8, 300, 000	6. 92
24, 000	4. 38	84, 000	4. 92	540, 000	5. 73	2, 400, 000	6. 38	8, 400, 000	6. 92
25, 000	4. 40	85, 000	4. 93	550, 000	5. 74	2, 500, 000	6. 40	8, 500, 000	6. 93
26, 000	4. 42	86, 000	4. 93	560, 000	5. 75	2, 600, 000	6. 42	8, 600, 000	6. 93
27, 000	4. 43	87, 000	4. 94	570, 000	5. 76	2, 700, 000	6. 43	8, 700, 000	6. 94
28, 000	4. 45	88, 000	4. 94	580, 000	5. 76	2, 800, 000	6. 45	8, 800, 000	6. 94
29, 000	4. 46	89, 000	4. 95	590, 000	5. 77	2, 900, 000	6. 46	8, 900, 000	6. 95
30, 000	4. 48	90, 000	4. 95	600, 000	5. 78	3, 000, 000	6. 48	9, 000, 000	6. 95
31, 000	4. 49	91, 000	4. 96	610, 000	5. 79	3, 100, 000	6. 49	9, 100, 000	6. 96
32, 000	4. 51	92, 000	4. 96	620, 000	5. 79	3, 200, 000	6. 51	9, 200, 000	6. 96
33, 000	4. 52	93, 000	4. 97	630, 000	5. 80	3, 300, 000	6. 52	9, 300, 000	6. 97
34, 000	4. 53	94, 000	4. 97	640, 000	5. 81	3, 400, 000	6. 53	9, 400, 000	6. 97
35, 000	4. 54	95, 000	4. 98	650, 000	5. 81	3, 500, 000	6. 54	9, 500, 000	6. 98
36, 000	4. 56	96, 000	4. 98	660, 000	5. 82	3, 600, 000	6. 56	9, 600, 000	6. 98
37, 000	4. 57	97, 000	4. 99	670, 000	5. 83	3, 700, 000	6. 57	9, 700, 000	6. 99
38, 000	4. 58	98, 000	4. 99	680, 000	5. 83	3, 800, 000	6. 58	9, 800, 000	6. 99
39, 000	4. 59	99, 000	4. 99	690, 000	5. 84	3, 900, 000	6. 59	9, 900, 000	6. 99
40, 000	4. 60	100, 000	5. 00	700, 000	5. 85	4, 000, 000	6. 60	10, 000, 000	7. 00
41, 000	4. 61	110, 000	5. 04	710, 000	5. 85	4, 100, 000	6. 61	11, 000, 000	7. 04
42, 000	4. 62	120, 000	5. 08	720, 000	5. 86	4, 200, 000	6. 62	12, 000, 000	7. 08
43, 000	4. 63	130, 000	5. 11	730, 000	5. 86	4, 300, 000	6. 63	13, 000, 000	7. 11
44, 000	4. 64	140, 000	5. 15	740, 000	5. 87	4, 400, 000	6. 64	14, 000, 000	7. 15
45, 000	4. 65	150, 000	5. 18	750, 000	5. 88	4, 500, 000	6. 65	15, 000, 000	7. 18
46, 000	4. 66	160, 000	5. 20	760, 000	5. 88	4, 600, 000	6. 66	16, 000, 000	7. 20
47, 000	4. 67	170, 000	5. 23	770, 000	5. 89	4, 700, 000	6. 67	17, 000, 000	7. 23
48, 000	4. 68	180, 000	5. 26	780, 000	5. 89	4, 800, 000	6. 68	18, 000, 000	7. 26
49, 000	4. 69	190, 000	5. 28	790, 000	5. 90	4, 900, 000	6. 69	19, 000, 000	7. 28
50, 000	4. 70	200, 000	5. 30	800, 000	5. 90	5, 000, 000	6. 70	20, 000, 000	7. 30
51, 000	4. 71	210, 000	5. 32	810, 000	5. 91	5, 100, 000	6. 71	30, 000, 000	7. 48
52, 000	4. 72	220, 000	5. 34	820, 000	5. 91	5, 200, 000	6. 72	40, 000, 000	7. 60
53, 000	4. 72	230, 000	5. 36	830, 000	5. 92	5, 300, 000	6. 72	50, 000, 000	7. 70
54, 000	4. 73	240, 000	5. 38	840, 000	5. 92	5, 400, 000	6. 73	60, 000, 000	7. 78
55, 000	4. 74	250, 000	5. 40	850, 000	5. 93	5, 500, 000	6. 74	70, 000, 000	7. 85
56, 000	4. 75	260, 000	5. 42	860, 000	5. 93	5, 600, 000	6. 75	80, 000, 000	7. 90
57, 000	4. 76	270, 000	5. 43	870, 000	5. 94	5, 700, 000	6. 76	90, 000, 000	7. 95
58, 000	4. 76	280, 000	5. 45	880, 000	5. 94	5, 800, 000	6. 76	100, 000, 000	8. 00
59, 000	4. 77	290, 000	5. 46	890, 000	5. 95	5, 900, 000	6. 77	200, 000, 000	8. 30
60, 000	4. 78	300, 000	5. 48	900, 000	5. 95	6, 000, 000	6. 78	300, 000, 000	8. 48

(2) Laboratory Examinations: All bacteriological examinations shall conform to the standard methods and technique as prescribed in the latest edition of the Standard Methods for the Examination of Dairy Products, published by the American Public Health Association. In the absence of laboratory facilities for bacteriological examinations, the medical officer should perform phosphatase tests for adequacy of pasteurization. Testing kits may be procured from Medical Supply Depots. They are identified in the Army-Navy Catalog of Medical Material as follows:

TABLE 1-3

Stock No.	Title	Unit	Cost
4-355-200----	MILK TESTING KIT, Pasteurization Scharer.	Each---	$19.85
4-355-400----	TABLET SET, MILK TESTING, Pasteurization.	Set----	6.71

In addition, bacteriological examinations may be made by local or state health departments on samples submitted by the medical officer immediately after their delivery.

(3) Use of Logarithmic Averages of Bacterial Counts: Based upon years of experience in the field of dairy sanitation, the U. S. Public Health Service has determined that fewer than four bacterial counts cannot be relied upon as fair bacteriological indication of a milk supply, and that the use of arithmetic averages will disqualify satisfactory supplies because of the occasional occurrence of an extremely high count in the best of dairies. In the light of these facts, the medical officer shall use the logarithmic average of the last four consecutive bacterial counts in passing judgment on the bacterial quality of a milk supply.

(4) Determination of Logarithmic Averages. To expedite calculations bacterial counts are reported to the nearest 1,000 when the total plate count does not exceed 100,000. From 100,000 to 1,000,000 they are reported to the nearest 10,000 and when above 1,000,000 they are reported to the nearest 100,000. In table II are recorded the logarithms and antilogs from 1,000 to 100,000,000. The bacterial counts should be entered on one side of the record sheet, and the logarithm of each count on the opposite side. To determine the logarithmic average, the average of the logarithms is determined, and the bacterial count which this represents is found in table 1-2. For example:

TABLE 1-4

Date	Count	Logarithms	Date	Count	Logarithms
July 6	15,000	4.18	July 27	13,000	4.11
July 13	130,000	5.11			
July 20	20,000	4.30	Total		17.70

$17.70 \div 4 = 4.42$ average logarithm. In table 1-3 the bacterial count opposite the logarithm 4.42 is 26,000 which is within acceptable limits. The use of arithmetic average in this case would have made this supply unacceptable as Type II, No. 1. When the average logarithm occurs opposite more than 1 bacterial count in table 1-3, use the lower figure.

(5) Inspection of Dairies. When milk is to be obtained from a source with which the medical officer is not familiar, he should ascertain if the milk is produced, pasteurized, and marketed under adequate sanitary supervision by the local or state health department. If satisfactory control by governmental agencies be doubtful, or if the bacterial counts or other evidence points to improper production or handling of the milk, the medical officer should inspect the producing farms and the pasteurizing plant in company with a representative of the local or state health department. The inspection should be made with reference to the Public Health Service Milk Ordinance and Code.

(6) Refrigeration. Immediately upon delivery all milk should be placed in refrigeration at a temperature lower than 45° F., and kept at such a temperature until it is served.

(7) Dispensing. The safest method of dispensing is by procurement and serving in individual one-half pint containers. The pouring lips of bottles containing milk or other beverages should not be submerged in water or covered by ice for cooling. Where use of individual containers is not practicable, the medical officer should recommend the provision of sanitary dispensing devices. Special stock pot types of dispensers are satisfactory if equipped with an easily cleaned sanitary valve. Open milk vats in serving lines should not be permitted. Ladling of milk should be prohibited. The pouring of milk from bulk containers into pitchers is a common practice not without danger from contamination. In no case should any milk be returned to the bulk container, nor should the bulk container be left outside the chill room. All milk should be used within 48 hours of delivery.

27. Fresh Milk Substitutes.--

(a) Description and Usage. Reconstituted, reconstructed and recombined milk are ambiguous terms that have been applied to various processes by which milk components, with or without the addition of other substances, are combined to make fresh milk substitutes. They may be used in areas where a shortage of satisfactory pasteurized fresh milk exists.

(b) Provision. Specifications, and Inspections.--

(1) The use and procurement of reconstituted milk is controlled by current instructions of the Bureau of Supplies and Accounts.

(2) All milk used in the so-called reconstituted milk, including the fresh fluid and the partially evaporated milk and cream, shall comply with current specifications. Sampling, testing, and inspections shall be made by the medical officer, as stated for pasteurized fresh milk.

(3) When reconstructed powdered milk (whole powdered milk plus potable water) is used, sampling, testing, refrigeration, dispensing, and inspections shall be made as stated for pasteurized fresh milk, except that the phosphatase test need not be performed.

(c) Sanitary Precautions to be Observed in Preparing Fresh Milk Substitutes.

(1) Personnel assigned to duties in the preparation, operation, and maintenance of equipment for producing fresh milk substitutes shall be subject to standards for selection and supervision of food handlers, as described in paragraph 17 of this chapter.

(2) The following are recommendations for the operation of "Mechanical Cows" and similar equipment that have been adopted by several naval activities when investigations have shown insanitary technique in the preparation of reconstituted milk.

I. Instructions for Operating "Mechanical Cow."

A. Preparation of Equipment Before Use.

1. Assemble equipment.

2. Prepare five gallons of chlorine solution in mixing vat. Solution should contain 100 p p m chlorine. (1/10 ounce high test calcium hypochlorite- 70% available chlorine- per 5 gallons of water).

3. Wash interior of mixing vat with chlorine solution using soft hair brush.

4. Pump chlorine solution through all parts of assembled equipment.

5. Catch solution as it runs off cooler and pour over the cooler again.

6. Drain cup of the emulsifier by removing it.

B. Production of Milk.

1. Fill jacket of mixing vat with water.
2. Fill mixing vat one-quarter full of potable water.
3. Heat to 80° F.
4. Add required amount of dried milk powder.
5. Agitate for five minutes at 80° F. or until milk powder is dissolved.
6. Fill mixing vat with correct amount of water.
7. Raise temperature of mix to 145° F.
8. Add butter if necessary.
9. HOLD AT 145° F. FOR THIRTY MINUTES, agitating mix during this time.
10. Turn mix from vat into feed cup of the emulsifier. Keep mix under agitation at all times.
11. Finished milk from cooler should be below 40° F.
12. Place finished product in clean cans and refrigerate below 40° F. as soon as possible.

C. Cleaning and Sterilizing of Equipment After Use.

1. Immediately rinse all equipment with lukewarm water. (100 to 120° F.).
2. Prepare tri-sodium phosphate solution in wash tank (one cup of powder to ten gallons of water).
3. Disassemble all equipment and place all parts in wash tank.
4. Scrub all parts inside and outside with a stiff brush.
5. Rinse parts in hot water. (180° F.).
6. Place parts on rack to drain and dry. Leave on rack until time of using.
7. Pasteurizing tank and cooler should be washed with a brush using tri-sodium phosphate solution. These should be steam-rinsed after cleaning.

D. Cleaning of Milk Cans.

1. Wash all cans and lids with brush in tri-sodium phosphate solution.
2. Sterilize with steam.
3. Invert on rack to drain and dry.

II. Instructions for Preparing Milk Substitutes with Equipment Other Than a "Mechanical Cow."

A. Preparation of Milk.

1. Milk mixtures shall be prepared on the same morning of their use.
2. Not more than two hours shall elapse between the time of preparation of the milk and its serving.
3. All utensils in which such mixtures are prepared shall be scrupulously cleaned, particularly before mixing.
4. All accessory implements used in this process shall be of such material that they can be readily sterilized. Wooden paddles are not to be used.
5. Unused milk may not be used again except for cooking purposes.
6. The use of chilled water for preparation of milk is permissable.
7. The mechanical mixing apparatus including bowl and whipper offers a suitable means of mixing reconstituted milk.
8. If standard milk cans are available they may be used to mix milk using a hand mixer. A suitable mixer can be made by constructing a plunger consisting of a perforated metal disc welded to a long rod.
9. Hand mixing devices shall be sufficiently long to prevent contamination of the milk by the hand of the operator.

28. Frozen Milk.

(a) Whole pasteurized, homogenized milk which has been frozen is available for use aboard hospital ships and transports. In the event that use of this product is considered essential under other conditions, an official request will be forwarded to the Bureau of Supplies and Accounts (Subsistence Division) together with detailed data to substantiate the request. Frozen milk requires special handling for best results and the following instructions apply:

(1) When delivered the milk is in a hard-frozen condition and must be placed immediately in a freezer held at 0° to 10° F. Zero temperature is preferred for this product.

(2) The corrugated shipping cases containing twelve one-quart paper containers shall be stacked top-side up in a tight pile and in such a manner as to facilitate the determination of dates of freezing in the individual cases. The procurement of frozen milk will be effected by Yards and Depots in such a manner that the product will be not more than thirty days old when issued to authorized vessels. All lots shall be carefully marked to insure that the stock bearing the earliest freezing date is issued first.

(3) Defrosting aboard ship will be accomplished by arranging the individual quart containers to permit a free circulation of air at room temperature (65° to 90° F.). The containers should be separated by at least three-quarters of an inch. Construction of a simple rack for this purpose will save time and space. Defrosting may be speeded up by gentle agitation during the later stages of thawing, or by the forced circulation of air around the containers by the use of a fan. Defrosting time varies from 3 to 8 hours depending upon the temperature of the frozen milk before defrosting, the temperature of the defrosting room and the amount of air circulation present.

(4) When thawing is complete the contents should be thoroughly mixed by turning the carton end-over-end several times by hand. If the milk will not be served for several hours, return individual containers to the cases and hold in chill room. Containers must be turned again before serving. In serving milk cold, pour directly from quart containers.

(5) The amount of frozen milk defrosted at one time should be limited to the quantity required for immediate issue. Milk which has been wholly or partially defrosted will not be refrozen.

29. Cream.--Cream procured for the general mess, ship's stores, or post exchanges shall be from healthy herds, produced, pasteurized, packaged, and distributed in a sanitary manner under the competent sanitary supervision of a local or state health department. The bacterial count after pasteurization should not exceed 50,000 per ml.

30. Ice Cream.--Ice cream served in the general mess, ship's stores, or post exchanges shall be produced in a sanitary manner, under competent sanitary supervision. The dairy

products used in its manufacture shall meet Federal specifications for pasteurized milk. The bacterial count of the ice cream shall not exceed 50,000 per ml. The following instructions should be adhered to in the sanitary manufacture of ice cream:

(a) The operator and the utensils must be scrupulously clean.

(b) The mixing vats, the ice cream freezer, and the cans for the final products must be cleaned thoroughly with hot water, soap, and brush after use.

(c) They are next rinsed with steaming hot water.

(d) This is followed by a rinse with cold water containing 5 ppm of residual chlorine.

(e) Rinse utensils with steaming hot water before using again.

(f) As soon as water is added to the mix, place it in the reefer and cover it.

(g) As soon as the mix is chilled sufficiently, transfer it directly to the freezer.

(h) As soon as the product emerges from the freezer into the containers, place it immediately in the deep freeze chest.

(i) Always keep the product covered in the process of manufacture.

(j) Never freeze ice cream once it has melted.

(k) Install freezer in a separate room which is kept locked. This is to keep down the number of persons having access to ice cream.

(1) To carry out the above instructions effectively, the number of persons concerned with the manufacture of ice cream should be limited to one or two.

Section VI.--STORAGE AND PRESERVATION OF PROVISIONS

31. Supply Dumps.--Supply dumps should be protected against pilferage and against infestation by rodents and insects that will attend the littering of the area by food residue and opened food containers. Pallets or platforms 12 to 18 inches high should be used wherever practicable to minimize rat harborages.

32. Canned Provisions.--Canned foods, with the exception of canned cooked whole ham and dried beef, should be stored in dry, cool, well-ventilated spaces wherever practicable and should be placed on shelves or pallets. It is desirable that they be so arranged that they are used in the order received

and with reference to the date of packing to prevent undue aging of stocks on hand. Canned cooked whole ham and dried beef are not sterile, are perishable, and should be stored in the chill room.

33. Dry Provisions.

(a) Dry provisions in general should be stored in a manner similar to canned goods, with the extra provision that ratproof containers or compartments be used wherever practicable.

(b) Bread should be protected against flies, roaches, mice, and rats. All bread should be kept, if practicable, in wax paper wrappers until needed. When returned from the mess hall it is placed in a bread basket and covered to prevent fly contamination.

34. Fruits and Vegetables.

(a) Proper storage and temperature conditions will prevent much loss among foods of this type. Fruits and vegetables may be divided into three groups, as follows:

(1) Group I: Recommended storage temperature 32° - 33° F. and a relative humidity of 85 to 90 percent: Apples, cranberries, grapefruit, oranges, pears, plums, prunes, beans (snap and lima), beets (topped), celery, lettuce (Iceberg), parsnips, sweet peppers, rutabagas, turnips (topped).

(2) Group II: Recommended storage temperature 40° to 42° F. and a relative humidity of 85 to 90 percent: Honeydew melons, onions, and Irish potatoes. Compartments in which potatoes are stored must be kept dark. Onions keep well in the dark at 32° F. and a relative humidity of 70 to 75 percent, but should not be stored with Group I on account of their effect on taste of such articles as apples and grapefruit.

(3) Group III: Recommended storage temperature 55° to 58° F. and a relative humidity of about 85 percent: Lemons, sweet potatoes, winter varieties of squash, and green mature tomatoes.

(b) It should be remembered that the concentration of carbon dioxide developing from the respiration of vegetables and fruits if a closed compartment (such as the hold of a vessel) may reach a dangerous level; i.e. 5 percent or above. Deaths have been reported for men who descended into holds filled with fruit such as bananas. The precautions to be observed against these hazards are included in Chapter III: Ventilation.

35. Dehydrated Vegetables.--Dried vegetables are particularly useful during time of war because the shipping weight of the dried product is about one-fourth that of the fresh product

and the storage space is greatly decreased. Cold storage is not required for their preservation. Their storage life is limited to about 6 months at high temperatures. For further information concerning dehydrated foods consult "The Cook Book of the U. S. Navy" and War Department Technical Bulletin, TBQM 45, "Dehydrated Foods."

Section VII.--REFRIGERATION AND PRESERVATION OF PROVISIONS

36. Refrigeration.--All readily perishable food and drink shall be kept refrigerated at the proper temperature except when being prepared or served. Waste water from refrigeration equipment shall be disposed of properly. For complete information on storage and care of provisions, refer to Bureau Supplies and Accounts Manual,

37. General Use and Care of Refrigerators.

(a) Although food should be conserved when safely possible, many instances of injudicious saving occur. The storage in coolers of left-over chicken salad, creamed chicken, potato salad, macaroni and cheese, spaghetti and meat balls, custard pies, cream puffs, and the like especially is fraught with danger. If unable to serve them within 12 to 36 hours, it is wiser to discard, take the loss, and prepare less the next time.

(b) Foods should be neatly arranged in the refrigerator, pans of food not being stacked on one another or placed on deck. The racks should be cleansed with warm soapy water weekly at least. Decks should be cleansed daily and scrubbed with hot soapy water every week at least. Meat hooks should be cleaned after use. It is well to have clean extra hooks kept in a box in the refrigerator ready for use.

(c) Over-loading decreases the efficiency, makes cleansing more difficult and interferes with sanitation inspection of refrigerators.

38. Fresh Meats.

(a) For complete information on this subject, the medical officer should refer to this section in "The Meat Handbook of the U. S. Navy," Bureau of Supplies and Accounts Publication No. 55. Table No. 1-5 taken from the Bureau of Supplies and Accounts Manual, gives approximate maximum storage periods for representative meat items at various storage temperatures and should serve as a general guide for the Medical Department and commissary personnel. The table is based on the following temperatures, recommended as optimum for refrigerated spaces ashore and afloat; chill space, 30° to 34° F.; freezer space, 0° F., or lower preferred, thaw room, 36° to 38° F. The storage periods shown in Group I and Group II of Table 1-5

below are based on approximate total storage life of the product. Therefore, in estimating the expected storage life of a commodity, the period from the date of inspection at the meat packing plant to the date of delivery indicates the amount of storage life already "used up." An explanation for each of the three storage groups shown in the table follows:

(b) Group I.--Chill Space: the approximate storage periods listed here are based upon receipt of the meat items in "chilled" rather than "frozen" state. A chilled product is that which has never been frozen.

(c) Group II.--Freezer Space: all frozen meat keeps best at temperatures of 0° F. or below. Since this is not always possible, the temperature nearest 0° F. should be sought and 5° to 10° F. is far more desirable than 15° F. The listed storage period is only approximate and is based upon good storage conditions; condition at receipt is most important in determining the storage period since a part of the normal storage life has already been consumed prior to delivery to the activity concerned.

(d) Group III.--Maximum Holding Time After Breakout From Freezer: All frozen meat should be thawed out gradually under refrigeration and used soon after thawing. The ideal temperature for the thawing period is 36° to 38° F.

(1) Never thaw frozen meat in water.

(2) Packaged meats may be removed from the package but should not be unwrapped for the thawing period.

(3) All thawed fresh frozen meat should be cooked promptly. Refreezing of items once frozen, then thawed, should not be done except as an emergency measure. All thawed meat is highly perishable.

TABLE 1-5--STORAGE DATA RELATIVE TO CHILLED, FROZEN, CURED, AND SMOKED MEATS AND MEAT PRODUCTS

APPROXIMATE MAXIMUM STORAGE PERIODS

(From Manual, Bureau Supplies and Accounts)

Commodity	Group I Chill space		Group II Freezer space		Group III Maximum holding time after breakout from freezer	
	Stored at 30°-34°F.	Stored at 38°-40°F.	Stored at 0°F.	Stored at 15°F.	Held at 36°-38°F.	Held at 70°F.
Carcasses and cuts:						
Beef, quarters or cuts	10-14 days	5-7 days	9-12 mo.	3-5 mo.	5-6 days	2 days.
Beef, boneless, frozen	----	----	12-14 mo.	4-6 mo.	6-7 days	2 days.
Pork, fresh, cuts	3-5 days	1-2 days	4-6 mo.	2-3 mo.	2-3 days	1 day.
Veal, carcass, sides, cuts, carcass	5-7 days	2-3 days	6-8 mo.	3-4 mo.	3-4 days	24-36 hr.
Lamb and mutton--saddle or cuts	8-10 days	4-6 days	8-10 mo.	3-5 mo.	4-5 days	24-36 hr.
Variety meats:						
Liver	2-3 days	1 day	4-6 mo.	2 mo.	1-2 days	12-16 hr.
Hearts, beef	3-4 days	2 days	5-7 mo.	2 mo.	1-2 days	18 hr.
Brains	2-3 days	1 day	3-4 mo.	6-8 weeks	1 day	12 hr.
Kidneys	2-3 days	1 day	4-6 mo.	6-8 weeks	1-2 days	12-16 hr.
Sausage:						
Bologna	10-14 days	5-7 days	4-6 mo.	2 mo.	5-7 days	2-3 days.
Frankfurters	1 week	3-4 days	4-6 mo.	6-8 weeks	4-5 days	1-2 days.
Luncheon meat, fresh	1 week	3-4 days	4-6 mo.	2 mo.	4-5 days	1-2 days.
Liver sausage	10-12 days	5-7 days	4-5 mo.	1-2 mo.	5-6 days	2-3 days.
Pork sausage	3-4 days	1 day	3-5 mo.	6-8 weeks	1 day	12-16 hr.
Cured and smoked:						
Bacon, slab, domestic	2 mo.	2-4 weeks	7-9 mo.	4-6 mo.	2-3 weeks	1 week.
Bacon, sliced, domestic	1 mo.	2 weeks	4-6 mo.	2-3 mo.	1 week	3-5 days.
Bacon, slab, overseas	5-7 mo.	3-4 mo.	1-2 years	1 year	4-6 weeks	2-3 weeks.
Bacon, Canadian style	4-6 weeks	2-3 weeks	4-6 mo.	2-3 mo.	10-14 days	4-5 days.
Ham, domestic	4-6 weeks	2-3 weeks	6-8 mo.	4-5 mo.	2-3 weeks	1 week.
Ham, overseas	3-5 mo.	2-3 mo.	1-2 years	9-12 mo.	1 mo.	2-3 weeks.
Pork, bellies (salt)	4-6 mo.	2-4 mo.	1-2 years	1 year	1 mo.	2-3 weeks.

TABLE 1-5--STORAGE DATA RELATIVE TO CHILLED, FROZEN, CURED, AND SMOKED MEATS AND MEAT PRODUCTS--Continued

APPROXIMATE MAXIMUM STORAGE PERIODS

(From Manual, Bureau Supplies and Accounts)

Cured and smoked--Continued:						
Beef, corned (in boxes)	4-6 weeks	1-2 weeks	4-6 mo.	2-3 mo.	1-2 weeks	3-5 days.
Beef, corned (in barrels) pickle	4-6 mo.	2-3 mo.	----------	----------	----------	----------
Miscellaneous items:						
Ham, whole, canned	6-8 mo.	4-5 mo.	----------	----------	----------	----------
Beef, canned, dried, sliced	7-9 mo.	5-6 mo.	----------	----------	----------	----------
Lard, "War," Type I	7-9 mo.	5-6 mo.	1 year	8 mo.	3 mo.	1 mo.
Lard, "War," Type II	10-12 mo.	7-9 mo.	2 years	1 year	6 mo.	2 mo.
Shortening, vegetable	7-9 mo.	5-6 mo.	18 mo.	1 year	3 mo.	----------
Fish	1-2 days	1 day	3-5 mo.	4-6 weeks	1 day	As soon as thawed.
Poultry	3-4 days	1 day	6 mo.	3 mo.	1 day	As soon as thawed.

39. Dairy and Poultry Products.--Dairy and poultry products should be refrigerated as follows:

	Degrees F.
Fluid milk	31 - 33
Cream	31 - 33
Butter, for holding not longer than 1 month	31 - 33
Butter, for holding longer than 1 month	0
Cheese, Cheddar, for not longer than 2 months	38 - 40
Cheese, Cheddar, for longer than 2 months	31 - 33
Eggs, fresh, shell, for longer than 1 month	31 - 33

40. Fresh Fish and Fowl.--All fresh fowl, fish, oysters, etc., should be used as soon as possible. They should never be held longer than 24 hours at a temperature of 34° F. to 38° F.

41. Surface Mold of Hams and Bacon.--Hams and bacon which have been individually wrapped in one or more layers of paper have a tendency to retain on the surface any moisture which may have come from the product after wrapping. This moisture in a measure stimulates mold or bacterial growth if hams so wrapped are held at temperatures of 45° F. or above for a considerable length of time. Mold will grow on a surface, and the surface of the meat will become more or less slimy due to bacterial growth. Surface slime and mold make the hams unattractive and unpleasant to handle. To the uninitiated such hams may appear spoiled. However, surface mold and sliminess on hams rarely, if ever, render them unsatisfactory for food and they should not be surveyed or rejected for surface mold and slime alone. In most cases where this condition has been allowed to develop on hams and bacon, the product can generally be overhauled by trained commissary personnel in such a way that it is perfectly fit for food.

42. Use of Cracked Ice.--Ice exposed to contamination should not be used in drinks, unless rinsed off with potable water and then chipped or ground in the establishments where used. Ice for this purpose taken from wet boxes should be thoroughly rinsed.

Section VIII.--PRESERVATION OF PREPARED FOODS

43. Prepared Foods.--No prepared food should be permitted to remain at room temperature for more than four hours. Cooked ham, hash, chicken-a-la-king, fish of any type, meat or potato salads, fowl dressing and cream-filled pastries should not be allowed to remain at room temperature for longer than 2 hours (cumulated time) prior to consumption. As soon

as such foods are cool enough to handle they should be placed in shallow pans to a depth of not greater than 3 inches and put in the chill box until just prior to serving, if it is intended that such foods shall be held longer than 2 hours.

44. Dehydrated foods after reconstitution should not be allowed to remain at room temperature more than three hours from the time water is added until served.

45. Quick-frozen foods which have been defrosted are highly perishable, and should be used immediately after defrosting.

Section IX.--PREVENTION OF FOOD POISONING

46. General.--While food usually is considered in its relation to the maintenance of bodily health and efficiency it is sometimes injurious to health. Animal foods convey infections or have properties injurious to health more frequently than those obtained from plants, and meat and milk are the principal offenders.

Food may affect health as a result of: (1) Natural poisons contained in it as some mushrooms, some fish, etc.; (2) Animal parasites or their eggs or larvae contained in or conveyed by foods; (3) Bacteria conveyed by both animal and vegetable foods, as tubercle bacilli, typhoid, paratyphoid, and dysentery bacilli, streptococci etc.; (4) Toxins developing in foods as a result of bacterial growth, as staphylococcus enterotoxin, botulism; (5) Special poisons contained in foods, as solanin in sprouted potatoes; (6) Poisons accidentally or purposely added, as arsenic, lead, acids, insects powders; etc.; (7) Amount, too little or too much; (8) Composition, an unbalanced diet; (9) Faulty digestion or disturbances of metabolism; and (10) Idiosyncrasy to certain foods.

Experience has shown that more than one-half of all reported food poisoning outbreaks are the result of gross carelessness and deficiencies in messing sanitation or insanitary food handling. Outbreaks can be prevented by rigid maintenance of high standards in messing sanitation and food handling. Precautions with regard to food handler personnel are presented in this chapter, section III, article 17. Commissary personnel should understand the ways, i.e., handling, slicing, chopping, pouring, stirring, etc., by which pathogenic organisms are introduced into food that will serve as a culture medium and they must realize the necessity for adequate refrigeration (below 45 °F.) if serving of such food is to be delayed for a period of time. They should remember that uncovered containers of food, especially milk and other dairy products, in-

vite contamination from a number of sources including droplet infection.

47. Routine Precautions.--Certain insanitary practices are frequently associated with food poisoning, outbreaks of gastro-enteritis, and respiratory infections.

(a) Constant supervision is required to prevent the common practice of washing mess gear in water which is over 140° F and subsequent sterilization in water below the standard temperature of 180°F. Adequate facilities must be provided (in most instances "booster heaters" are required) to maintain a continuous flow of water at the minimum safe "sterilization" temperatures.

(b) Under no circumstances should drying of mess gear after washing and sterilizing be done by means other than air drying. The use of dish towels and other cloths for this purpose should not be permitted.

48. Food poisoning can cause acute attacks of illness in more men in a short time than any other condition. The term "food poisoning" is conventionally divided into two groups, food intoxication and food infection.

49. Food intoxication is due to a specific toxin produced outside the body, for example the toxin of botulism. Botulism is no longer a problem except in home-canned vegetables and meats. Other organisms cause food intoxication by producing toxins the exact nature of which is imperfectly understood. These toxins are formed under suitable conditions usually by staphylococci, occasionally by streptococci, and rarely by coliform, proteus, and possibly salmonella organisms. The general symptoms of food intoxication, caused by other than the Clostridium botulinum, are similar to those due to food infection, (i. e. nausea, vomiting and diarrhea), but the time interval of onset is shorter--half an hour to 4 hours--vomiting is more violent, and prostration more severe, there is usually less fever and recovery is more rapid.

The type of food associated with such outbreaks varies considerably. Ham is one of the most common foods. Others include canned or potted meat or fish, pressed tongue, beef, cheese or milk products, potato salad and macaroni salad. The usual source of the germs which cause this form of food intoxication come from boils, pimples, and infected cuts on the hands of those who prepared the food.

Besides the toxins or poisons produced by bacterial growth, certain foods are inherently poisonous. The following cause predominantly nervous symptoms, (weakness, or paralysis, numbness, tingling of ears, apprehension, and finally death) toadstools, hemlock, mussels in California during the summer,

tropical fish such as toadfish, puffer fish, certain members of the jack fish family, and in tropical waters at certain seasons of the year, barracuda.

Metallic poisons may be arsenic as residues of spray on fruit, or cadmium or zinc dissolved by acid foods such as lemonade, jello, tomatoes, etc. from cadmium plated or galvanized iron cans. (Ice trays in refrigerators are particularly dangerous if cadmium plated). Metallic poisons generally cause violent nausea, vomiting and diarrhea very shortly after ingestion.

50. Food infection is usually caused by a specific group of organisms, namely the Salmonella group, but occasionally the Dysentery group. Food infection is characterized by a sudden onset with headache, followed by nausea, vomiting, diarrhea, abdominal pain or distress, prostration, and sometimes fever, and usually commencing from 6 to 24 hours after ingestion of food. The causative organism may be revealed by examination of the vomitus and feces.

The great majority of outbreaks are caused by meat or meat mixtures. The meat may come from an animal infected during life with a specific organism; or it may come from a healthy animal and be infected during the process of slaughtering and handling. Such sources of infections are best controlled by meat inspectors at slaughter houses. Food handlers with hands not thoroughly washed after leaving the toilet are often the source and the means of conveying contamination to food. The entrails of fowl contaminating the butcher block or cutting table is another common source. Food may also be infected by flies, cockroaches, rats, mice, and polluted water when used in cooking and preparation of food.

Food which most often cause food poisoning are mixtures with meat as a basis, such as ham, hash, meat or fowl, veal and cream pies, meat, crab, lobster and chicken salads, hamburger steak; and cold sliced meat. Veal mixtures are a frequent cause. Ham is most commonly infected with staphylococcus because of the common practice of boning and slicing hours before serving. Milk and egg products also have been reported as causes of outbreaks.

Foods that have caused trouble have the following in common: they provide a good medium for growth of bacteria. They are first contaminated at some point in preparation and are then allowed to stand in a warm place several hours, in some instances over night; and lastly are served cold or with inadequate recooking. If they have been infected with one of the causative organisms, it may be readily seen that with moisture,

a good protein food supply, and warmth, there is every desirable condition present for a large growth of bacteria and the production of much toxin.

The filling of cream puffs, cream pies, and custards and various sauces made from milk and cream have been the cause of outbreaks. Mixing of salads by hand, if the salad dressing or other ingredients will support bacterial growth, is another cause.

It is important to remember that the organisms which cause food infection do not necessarily cause any alteration in the normal appearance, odor, or taste of the food. A classic example of this occurred in connection with an outbreak in Ghent, Belgium. A meat inspector was so certain that the suspected meat had no connection with the trouble that he ate three slices to demonstrate their harmlessness. He suffered a severe attack of gastro-enteritis and died five days later. Bacterium enteridis was isolated from his viscera at autopsy.

51. The preventive measures are plainly indicated by the sources of the infection. Meats should be procured only from carefully inspected slaughter houses, and cured as well as uncured meats should be properly refrigerated.

On board ships, no food, especially meat mixtures, should be prepared and then set aside to be served at a subsequent meal. The time between the preparation and serving of the food should be reduced to a minimum. If it becomes necessary to hold over any food, it should be put in shallow pans and stored in a cold refrigerator as soon as possible and kept cold until it is to be served or prepared for serving. Refrigerator stowage must be watched to assure free circulation of cold air to all sides of the stored food.

Experience has indicated that it is not good policy to prepare sandwiches containing meat, fish and fowl, or meat products that are to be served several hours after preparation unless the sandwiches can be kept under constant refrigeration. If made from canned meats or meat products, they should be prepared only by opening the can immediately before serving. If galley cooked meats are used, the sandwiches should be prepared in the galley and kept constantly refrigerated during the time prior to serving. It is suggested that the unopened cans of meat or meat products with the necessary bread be sent ashore for sandwich preparations by beach parties just before serving whenever there is a possibility that meat sandwiches prepared on board ship or at a shore station would not be consumed within three to four hours after preparation.

A high standard of sanitation in the galley and butcher's shop is very important. The personal hygiene of the cooks and

handlers of food should be looked into; particularly their attention to the important detail of thoroughly washing their hands after visiting the toilet. They should be watched constantly for symptoms of intestinal disturbances and no men allowed to handle or prepare food who are suffering from any signs of gastro-intestinal upset. After suffering with dysentery, a food handler should be excluded from food handling for at least a month unless bacteriological examinations have shown him to be free of dysentery germs at an earlier date.

52. Investigation.--Immediately after an outbreak occurs effort should be made to get samples of the last meal served so that they can be examined in a laboratory. As soon as care of the sick permits, an epidemiological study of the outbreak should be undertaken. The patients should be questioned regarding the foods eaten and the messes in which they were eaten. Unaffected members of the same mess should be interrogated as to whether they ate the same foods. Men frequently eat the same foods, but because of immunity, eating very small portions, or an unequal distribution of the infection throughout the food mass, are not affected.

The following information should be gathered by questioning each person affected. This information could be charted to facilitate a conclusion as to the causative agent:

(a) Name and rate.

(b) Time illness was noticed.

(c) What was eaten during the past 24 hours at meals and food not on the menu.

(d) What symptoms were experienced, i. e., nausea, vomiting, diarrhea, and other conditions.

(e) Have symptoms been experienced previously and when.

(f) Other remarks that may be elicited by further questioning.

By careful study of the above information one can arrive at a fairly accurate idea of the food responsible for the outbreak. Certain foods, by their nature, would ordinarily be suspected, others not. If some men were affected yet did not eat the suspected food, that food should be ruled out. Specimens of the urine and feces from the more severe cases should be collected and sent as soon as possible to the nearest hospital or other clinical laboratory for examination.

Food handlers should be brought under observation for medical and bacteriological examination to determine possible origin, whether from infections of the skin or bowel discharges. The germs from tonsillitis and sore throats may occasionally be at fault.

In addition to the above, as soon as practicable, after it is evident that a food infection has occurred, the galley and mess hall should be investigated to determine the exact menu served, when and by whom each article of food was prepared, what time it was prepared, how it was stored before it was served and by whom it was served.

Following an outbreak, effort should be made to obtain specimens of the responsible food and have them examined at the nearest naval hospital or epidemiological laboratory. Specimens in sterile containers can be sent to the U. S. Naval Medical Center, Bethesda, Maryland.

Section X.--CONTAMINATION OF FOOD AND WATER BY CHEMICAL WARFARE AGENTS

53. Contamination of food by chemical warfare agent.

(a) Contamination of foodstuffs by chemical warfare agents may occur from contact with vapor, spray or splashes of liquid, or solid chemicals. Unprotected food supplies may be so contaminated that their consumption produces gastro-intestinal irritation or systemic poisoning. The blister gases and agents containing arsenic are the most dangerous.

(b) While decontamination may be difficult, large stores of foods must not be hastily condemned until available means for decontamination have been considered. Scarcity of supplies may at times make reclamation necessary. Prompt segregation of the heavily contaminated portions may prevent or minimize contamination of the remainder. Generally, foods not especially packed in protective packages constitute the major difficulty. The present method of packaging foods for overseas shipment minimizes the dangers of contamination. With such packaging in most cases decontamination of the outer packing only is required.

(c) The blister gases and chlorpicrin are readily soluble in fats. They will be absorbed by foods of high fat content, and because of diffusion throughout the material, it may be impossible to remove them. Coagulation of protein by agents which are acidic or acid formers in high protein foods may limit diffusion of the agent. Hydrolysis of acid-forming gases in foods of high water content causes decomposition products which render the food unpalatable. Foods of low water and fat content will be relatively less easily contaminated by chemical agents and less difficult to decontaminate.

54. Decontamination of Food.

(a) General:

(1) The most effective and practical measures for decontaminating food include washing with water or 2 to 5 percent sodium bicarbonate solution, trimming of exposed surfaces, serrating adequately, and boiling in water. These measures may be ineffective if the decomposition products are toxic, as in the case of the arsenicals. In general, food exposed to low vapor concentrations of chemical agents can be reclaimed by these procedures. It is impracticable to reclaim provisions that have been heavily contaminated by liquid droplets of blister gases. Unpackaged foods on which chemical agents can be seen with the unaided eye should be considered spoiled and their decontamination impracticable.

(2) In determining the disposition of packaged and stored supplies which have been contaminated, consideration must be given to the type of packaging.

(b) Blister gases:

(1) When contaminated with liquid mustard or a liquid nitrogen mustard, foods of high water or fat content are unfit for consumption and reclamation is not practical. When foods have been exposed to blister gas vapor, they can be reclaimed by washing with soda solutions and rinsing with clear water, intensive cooking, or in the case of dry provisions, by 24 to 48 hours' aeration. Lean meat can be reclaimed by boiling in water for one-half hour or more, or in the case of the nitrogen mustards, with a 2 percent solution of baking soda. The water must be discarded after boiling.

(2) Lewisite, ethyldichlorarsine, methyldichlorarsine, and phenyldichlorarsine readily hydrolyze to form poisonous arsenical oxides. Foods contaminated with these agents cannot be reclaimed.

(c) Choking gases: This group of agents offers relatively little danger to food products. With the exception of chlorpicrin, these agents decompose rapidly upon contact with the water in foods, to form comparatively harmless compounds which may alter the flavor. Decontamination can be accomplished by washing, supplemented, where possible, by aeration. Chlorpicrin is slightly soluble in water, and is soluble in fat and most

organic solvents. Its removal from foods of low water and fat content can be accomplished by aeration.

(d) Tear gases and vomiting gases:

(1) Large stocks of well packaged supplies probably cannot be contaminated with a sufficient quantity of the tear gases or vomiting gases to warrant their destruction. However, these agents are not easily decomposed by hydrolysis and it is difficult to reclaim poorly packaged foods heavily contaminated by them.

(2) Dry provisions contaminated by tear gas vapor can be decontaminated by aeration.

(e) Screening smokes:

(1) Hexachlorethane (HC), titanium tetrachloride (FM), sulfur trioxide-chlorsulfonic acid solution (FS) and white phosphorus (WP) smokes are nontoxic. They may alter the taste of foods by acids produced on contact with moisture, but do no damage otherwise.

(2) Liquid titanium tetrachloride (FM) can be washed from foods. Liquid sulfur trioxide-chlorsulfonic acid solution (FS) is highly corrosive and forms strong acids on contact with moisture. It may render unfit for use food which cannot be washed readily. After trimming, washing, or cooking, if the food does not taste too acid, it is safe to use.

(3) Unburned particles of white phosphorous are poisonous and must be removed from foods. Fats and oils may dissolve poisonous amounts of the agent and should be discarded.

(f) Other agents: Carbon monoxide, arsine, and hydrocyanic acid will have little effect upon food supplies. Hydrocyanic acid is water soluble and foods with high water content may become unfit for consumption after exposure to high concentrations of that agent.

(g) Meat from gassed animals.--It may be necessary to use animals for food after they have been exposed to chemical warfare agent. Economy may justify the early slaughter of exposed animals before the effect of such exposure is shown. If such animals are slaughtered in an approved manner in the preliminary stages of poisoning and all tissues exposed to the gas (lungs and other areas) are discarded, there is no objection to the consumption of the meat, provided the animals pass an otherwise satisfactory meat inspection. This is true even of

animals poisoned by arsenical agents, since the edible tissue will contain amounts of arsenic too small to be toxic. Organs such as the liver, brain, heart, kidneys, and lungs will contain relatively more arsenic than the musculature, and should be discarded. The meat should be well cooked.

Section XI.--EMERGENCY RATIONS

55. Army emergency rations are used by the Navy and Marine Corps under certain conditions. The various Army field rations are described in War Department Technical Bulletin TB Med 141, from which the following information has been abstracted.

56. "B" ration and modification thereof.--This ration, known also as Expeditionary Force Ration No. 1, is used overseas where organized messing operations are possible. It is composed mainly of canned or otherwise preserved items and will vary somewhat depending on the availability of transportation and local supply. The Quartermaster Corps supplements this ration with fresh, frozen meat and fresh fruit wherever possible. Issue charts and menus for tropical temperature and cold climates have been prepared by the Office of The Quartermaster General and published as War Department Circulars for the information and guidance of all concerned in the various theaters of operations. It is as much like the field ration A served in camps in the United States as possible, except that most of the food is canned or otherwise preserved, as by dehydration. The average nutritional composition of this B ration is shown in Table 1-6.

57. "10-in-1" Ration.

(a) This is a ration designed for use in support areas or by mobile forces in combat areas where cooking and messing in small groups is feasible. It is specially packaged in a fiberboard box capable of being carried on a packboard and with sufficient food for 10 men for 1 day or for 5 men for 2 days. Variety is afforded by five different menus and by the inclusion of a large number of components within menus.

(b) The components of this ration are being changed and improved. In general, the menus have the following components as packaged at the present time.

(1) Breakfast. Premixed, ready-to-eat cereal, breakfast meat, jam, coffee, milk, and sugar.

(2) Dinner. Meat or cheese, biscuits, candy and fruit, drink and desserts.

(3) Supper. Meat, vegetables, biscuits, Army spread, candy, fruit bar or peanuts, cocoa or coffee.

(c) In addition to the food, there is a supply of cigarettes, water purification tablets, matches, salt, can opener, toilet paper, paper towels, and salt water soap.

(d) The ration is packaged so that breakfast and supper can be prepared for groups of troops, whereas the dinner is individually packed in two or three small containers in order to allow separation of members of the group during the day.

(e) The average nutritional value of the 10-in-1 ration (current production with 5 menus) is shown in table 1-6.

58. "C" Ration.

(a) This is a combat ration packed in typical three and one-half by three-inch cans for distribution of six cans per man per day. It is designed for use where no messing facilities are available. Three of the cans contain meat and vegetable items designated as "M" units, while the other three, designated "B" units, contain biscuits, various confections, and beverages (coffee, lemon or orange drink, or cocoa).

(b) The ration is packed in wooden cases each containing 8 rations with a total weight of 40 pounds. With the new ration there is an accessory packet containing cigarettes, matches, water purification tablets, toilet tissue, can opener, and chewing gum.

(c) The nutritional values of the original and the recently modified C rations are given in Table 1-6.

59. "K" Ration.--The original K ration was developed for paratroopers, but the resulting light weight and durable ration has found an important place as a combat ration for ground forces. It is used as an alternate to C ration.

(a) The ration is packaged in three units, each 7 by 2-5/8 by 1-5/8 inches, with a total weight of about 2 pounds 10 ounces. Twelve rations are packaged in one case.

(b) The present components of the K ration are:

(1) Breakfast. "K" biscuits, egg and meat product, fruit bar, coffee, sugar, cigarettes, and chewing gum.

(2) Dinner. "K" biscuits, cheese product, caramels, lemon juice powder, sugar, candy, chewing gum, matches, and cigarettes.

(3) Supper. "K" biscuits, meat product, bouillon, chocolate bar, cigarettes, chewing gum, and toilet tissue.

TABLE 1-6--NUTRITIONAL COMPOSITION OF RATIONS

Ration	Calories	Protein (gm.)	Fat (gm.)	Carbo-hydrate (gm.)	Calcium (gm.)	Iron (mg.)	Vitamin A (ilu.)	Thia-flavin (mg.)	Ribo-flavin (mg.)	Niacin (mg.)	Ascorbic acid (mg.)
Field ration B	3,915	122	141	532	0.996	27	9,430	1.98	2.42	26.7	103
C ration: 1 January 1945 forward	3,709	148	132	482	.925	23	5,430	2.7	3.0	23	112
10-in-1 ration: 1 January 1945 forward	4,150	130	170	525	1.150	25	3,100	2.7	3.6	26	75
K ration: 1 January 1945 forward	2,860	93	122	348	1.350	17	4,695	1.8	2.5	17	70

NOTES:
Food and Nutrition Board, National Research Council.
These rations are subject to further change, but proportions will probably be approximate.

(c) It should be emphasized that the synthetic fruit beverage powders in the K ration as well as in the 10-in-1 and C rations are included for the very important purpose of providing vitamin C in which these rations are otherwise poor. Each packet of this item contains 60 milligrams of ascorbic acid in stable form. All personnel should be indoctrinated in the importance of consuming this item.

(d) The nutritional value of the K ration (current product) is given in Table 1-6.

60. "D" Ration.--This is a ration for emergency survival conditions, to be used only when all other food supply is lacking. This ration is being revised. Because of its emergency purpose, it will not provide full caloric or vitamin requirements, but is designed only to give maximum energy for minimum weight, bulk, and residue.

61. Nutritional composition of rations.--For the purposes of information and comparison the Recommended Daily Allowances of the Food and Nutrition Board of the National Research Council and Minimum Allowances of Dietary Essentials for limited periods are included in Table 1-6 with the nutritional composition of the various rations described above. It will be noted that the rations in nearly every particular contain amounts of the various nutrients equal to those of the Recommended Allowances.

Chapter 2

Naval Housing

1. It is essential to the success of the mission of the Navy that quarters be provided ashore which are clean and comfortable, and which will insure the proper maintenance of health, welfare, and fighting efficiency of all personnel. To this end, plans for living quarters for naval personnel have been subjected to close and constant attention by the Medical Department to determine the basic requirements for air space, floor area, heating, ventilation, sanitary equipment, sleeping arrangements, and attendant features.

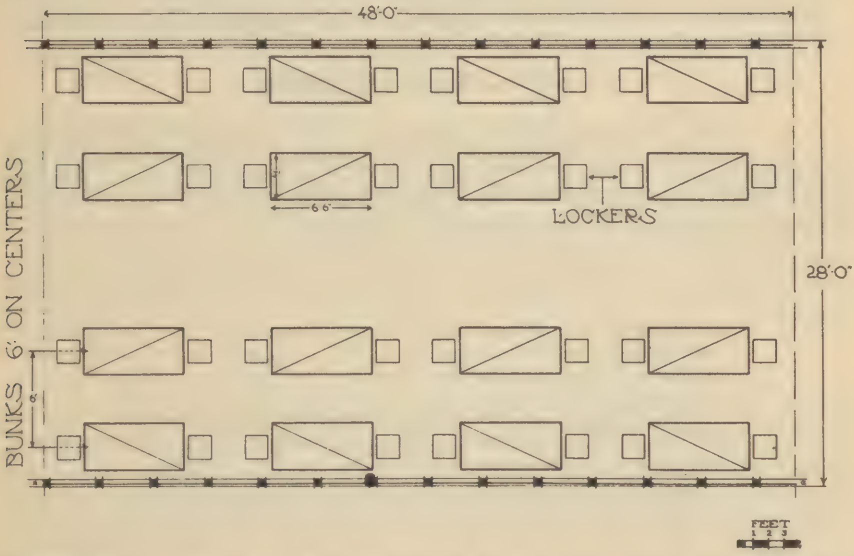

FIGURE 2-1.--METHOD OF ARRANGEMENT OF BUNKS CONSIDERED BY THE BUREAU OF MEDICINE AND SURGERY AS LEAST DESIRABLE AND NOT RECOMMENDED FOR USE IN NAVAL BARRACKS. PERSONNEL OCCUPYING THIS ROOM ARE SUBJECTED TO CROSS DRAFTS AND, FROM THE CENTER TO THE OUTSIDE OF THE ROOM, DIFFERENCES IN TEMPERATURE. THIS ARRANGEMENT INCREASES THE POSSIBILITY OF CROSS INFECTION OF COMMUNICABLE RESPIRATORY DISEASE FROM SNEEZING AND COUGHING. (COMPARE WITH FIGS. 2-2 AND 2-3.)

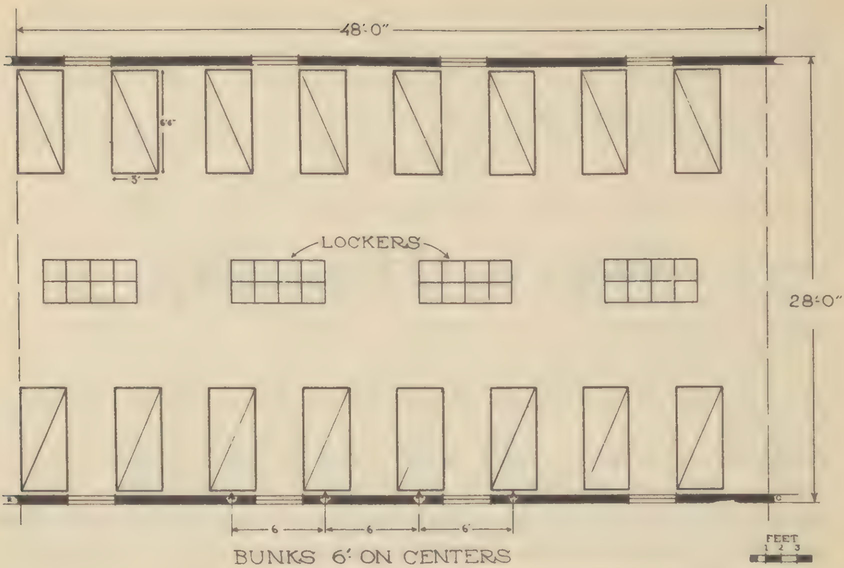

FIGURE 2-2.--ARRANGEMENT OF BUNKS REGARDED BY THE BUREAU OF MEDICINE AND SURGERY AS ACCEPTABLE BUT NOT OPTIMUM FOR NAVAL BARRACKS. NEARLY UNIFORM LIGHTING AND VENTILATION IS ASSURED EACH BUNK ARRANGED IN THIS MANNER BUT MAXIMUM ADVANTAGE IS NOT TAKEN OF SPACE AVAILABLE. (COMPARE WITH FIGS. 2-1 AND 2-3.)

Section I.--MEN'S BARRACKS

2. Area, Space, and Plumbing Fixture Requirements. Experience has shown that the following facilities are the minimum to meet the normal requirements for men's barracks. (From the Manual of the Medical Department.)

Facilities for Men's Barracks

Floor area: sq. ft. per man	50
Air space: cu. ft. per man	450
Distance between centerline of adjacent bunks, ft.	5
Water closets: number men per fixture	20
Lavatory: number men per fixture	5
Urinals: number men per fixture	25
Showers: number men per fixture	25
Scrub deck: number men per fixture	20

Figures given in this table are minimum standards recommended for large numbers of men. Facilities actually provided will frequently exceed these figures, but, where practical considerations permit, should never fall significantly short. The most important single factor in housing which affects the transmission of air-borne diseases appears to be the number of men

per room or barracks space, the more men present, the more rapid and extensive the spread of respiratory diseases.

3. Floor Area.--Floor area, given at 50 square feet per man, is chiefly a matter of "elbow room," and from the standpoint of health and sanitation is subordinate to air requirements.

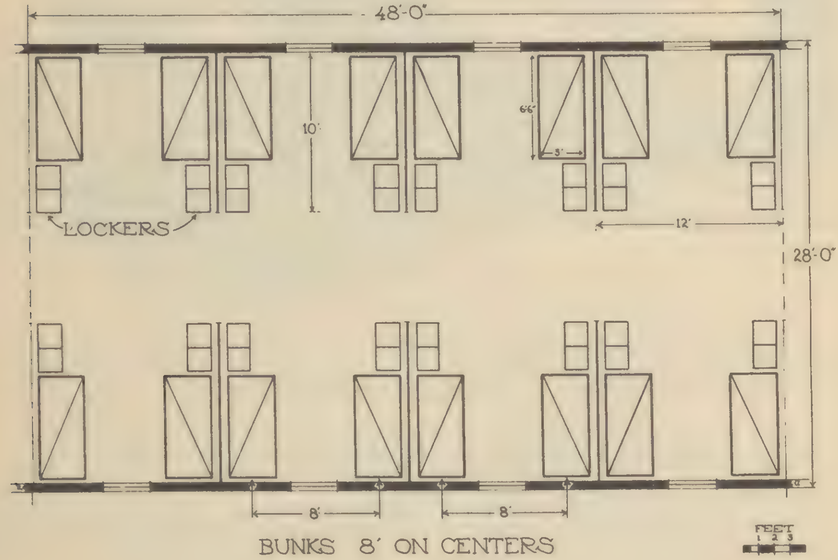

FIGURE 2-3.--ARRANGEMENT OF DORMITORY SPACE CONSIDERED AS OPTIMUM AND RECOMMENDED BY THE BUREAU OF MEDICINE AND SURGERY FOR ALL NAVAL BARRACKS. CUBICLE ARRANGEMENT, SHOWN IN DETAIL IN FIGURE 2-4, AFFORDS A DEGREE OF PRIVACY. GREATER DISTANCE BETWEEN ADJACENT BUNKS REDUCES THE POSSIBILITY OF CROSS INFECTION OF COMMUNICABLE RESPIRATORY DISEASE FROM SNEEZING AND COUGHING. COMPARISON WITH FIGURES 2-1 AND 2-2 CONFIRMS THAT AN EQUAL NUMBER OF BUNKS MAY BE INSTALLED IN THE SAME FLOOR SPACE IN EACH OF THESE THREE REPRESENTATIVE FLOOR PLANS.

4. Minimum Air Space.--The need for minimum air space is dictated by the requirements for replenishment air. Since most barracks are built without mechanical ventilation, fresh air introduced through open windows and roof ventilators must be depended upon to provide replenishment air. Air supplied in this manner is taken to be at the rate of 4 to 6 air changes per hour. Since approximately 1,800 cubic feet of fresh air per man per hour is a generally accepted minimum figure for replenishment air, a ventilation rate of four air changes per hour would just meet this requirement in barracks designed to provide 450 cubic feet of air space per occupant.

5. Distance between Bunks.--Five feet between the heads of sleeping men (i.e., between centerline of adjacent bunks) is regarded as the minimum safe distance to reduce the chances of infection from communicable respiratory diseases spread by sneezing and coughing. As an added factor of safety, personnel in adjacent bunks are usually required to sleep head to foot.

Section II.--WOMEN'S BARRACKS

6. Area, Space and Plumbing Fixture Requirements. Out of the studies which have been made of housing women in the Navy, a policy has been established setting forth certain minimum standards which must be met in any construction or conversion of quarters for WAVES. The minimum standards approved for WAVES housing are given in the following table.

Facilities for Women's Barracks

Floor area: sq. ft. per woman	50
Air space: cu. ft. per woman in dormitory space	450
Number in room or between bulkheads (maximum)	6
Water closets: number women per fixture	12
Lavatory: number women per fixture	6½
Showers: number women per fixture	10
Ironing board: number women per fixture	19
Laundry tray: number women per fixture	19

*Bathtubs are contraindicated for common use in any type of Navy housing

7. Messing Facilities.--Messing facilities must be provided for, but need not be separate from those of male personnel, except possibly to make available a number of separate tables for the women.

8. Medical Care Facilities.--Dispensary, sick bay, and hospital facilities must be provided for the WAVES on the same basis as those provided for the men of the Navy.

9. Recreation Facilities.--In the interests of morale, barracks and BOQ's for women should be provided with adequate space in the nature of a lounge for off-duty recreation and where visitors may be entertained. Recreation facilities outside the barracks and BOQ's should be provided equivalent to those provided for men. In large housing projects, a reception room, where visitors may be entertained should be combined with any separate recreation building which is provided.

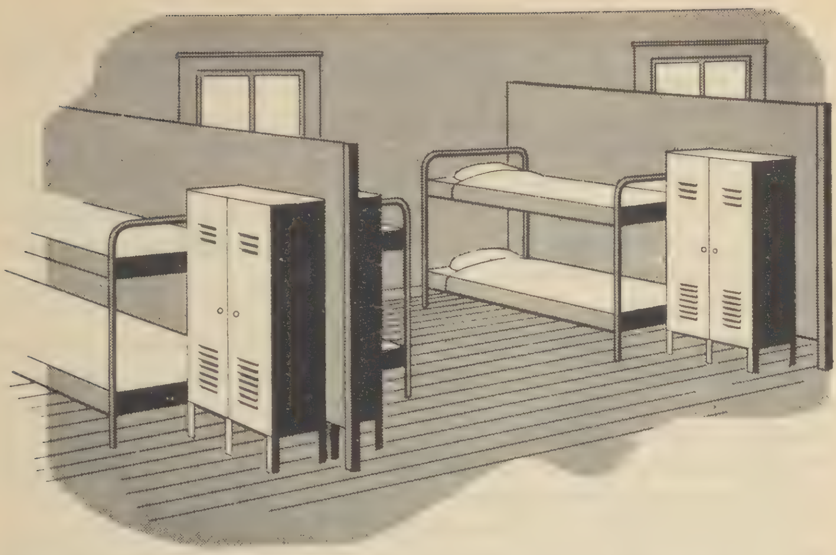

FIGURE 2-4.--ARRANGEMENT OF DORMITORY CUBICLE RECOMMENDED BY THE BUREAU OF MEDICINE AND SURGERY FOR NAVAL BARRACKS. THIS CUBICLE IS REPRESENTATIVE OF THOSE SHOWN IN THE RECOMMENDED GENERAL FLOOR PLAN IN FIGURE 2-3.

10. Cubicle Arrangement of Dormitory.--WAVES' sleeping quarters are usually constructed with separating bulkheads (fig. 2-4) between two single or double tier bunks. This provides a degree of privacy for occupants of the dormitories, a factor which is regarded as of definite psychologic benefit for WAVES personnel. This bulkhead arrangement also contributes to the control of respiratory diseases by cross infection, for the partitions serve to a degree to isolate adjacent cubicles, and a greater distance between heads of sleeping individuals is provided than otherwise possible.

Section III.--SANITARY CONSTRUCTION

11. Screening.--All sleeping quarters, recreation rooms, mess halls, galleys, inside garbage rooms, and heads should be screened to prevent the entrance of flies, mosquitoes, and other insects. Screen doors should open outward and should be spring closing. All air ducts should be screened. (See Chapters IX and X.)

12. Rat Proofing.

(a) Exclusion is regarded as the most satisfactory method for solution of the rat and mouse problem. All other methods provide only temporary relief.

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(b) Exclusion involves construction and maintenance of buildings so that no access is afforded for entrance of rats. It is a practicable procedure, and is desirable for all naval buildings--particularly personnel buildings. Essentially, exclusion calls for concrete floors, concrete foundation carried well into the ground (a minimum depth of 18"), screening of all ventilation openings with grills have a maximum aperture of 3/8'', cementing in or shething with metal all pipes or electrical conduits which enter buildings, and provisions for tight fitting of all doors and windows.

(c) For above ground construction, concrete or masonry is the most permanent rat proofing known. For structures of frame construction or wooden studs, single walls are preferable. Double walls, especially those sheathed on both sides with wood, provide an ideal retreat for rats and mice, and also provide runways to upper floors.

(d) Old buildings having double walls may often be made ratproof by fastening pieces of galvanized sheet iron over the base of the outer wall, removing the lowermost boards on the inside, and installing one of the stops shown in Fig. 2-6.

(e) Windows and ventilators close to the ground should be screened with 3/8" heavy mesh screen. If it is necessary to screen against insects, it is advisable to use both insect screen and rat screen, placing the heavier mesh screen on the outside. Above ground windows and doors, if the frames fit tightly, are adequately protected by fly screen.

13. <u>Shower Rooms.</u>

(a) Shower room floors should be so constructed as to drain readily and the room should be light and well ventilated to promote drying.

(b) Wooden gratings or duck boards in shower rooms can spread infection if not thoroughly cleaned and dried frequently. Their use is not recommended unless there is a duplicate set provided to permit alternate daily airing and sunning.

(c) Tile or terrazo flooring is regarded as the most desirable for shower rooms as it is easiest to keep clean.

(d) The provision of antiseptic foot baths at shower room entrances is of questionable value. There is little or no evidence that they contribute to the control of fungus infection.

14. <u>Plumbing System.</u>--The plumbing system should be constructed in accordance with the Bureau of Standards ''Recommended Minimum Requirements for Plumbing in Dwellings and Similar Buildings'' and plumbing fixtures should conform with the ''Federal Specifications for Plumbing Fixtures WW-P-541a.'' Cross-connections with polluted supplies, flushometer

toilet valves without vacuum breakers and submerged inlets are particularly to be prohibited.

Section IV.--BUILDING SANITATION

15. Whenever large groups of people live in a common dormitory room, the possibility of development and spread of communicable diseases exists. Only by constant attention to cleanliness of the quarters can this danger be kept at a minimum. Cleanliness of a military establishment, therefore, has long been recognized as a direct contribution to maintenance of health, high efficiency, and morale of personnel.

16. Airborne Infection.--Minute liquid droplets of saliva, and mucus and other secretions are expelled into the air by talking, coughing, sneezing, etc. The larger droplets settle to the floor and quickly evaporate; the smaller evaporate in the air. The nuclear residue remaining from the evaporation of these droplets may contain pathogenic micro-organisms which may remain suspended or settle to the floor, furniture, or bedding, and through circulation with dust remain a source of infection for an indefinite period of time. It is realized that the bacteria in the air count rises in direct proportion to the amount of dust in the air. Reducing the dust in air, therefore, is one effective way of reducing the sources of infection. The use of ultraviolet light and glycol vapor for sterilizing air is still experimental. These methods are costly and complicated, and will probably not be used outside contagious wards in hospitals, etc. Both methods should be accompanied by dust suppression.

17. Control of Airborne Infections by Dust Control.

(a) Encouraging results have been obtained in controlling dust by application of a light mineral oil emulsion to floors and bedding. An extremely high reduction in dust and bacteria count has been achieved by this method and preliminary evidence based upon experience with personnel living in "oiled" barracks points to a reduction in the incidence of respiratory diseases of bacterial origin. Since air-borne dust is not the major means of transmission, complete dust control at best may reduce the incidence of respiratory disease only 25 percent or less.

(b) The materials and procedure recommended for oiling of floors and bedding is as follows:

(1) For floors: The oil used is a so-called "deck emulsion" consisting of light mineral oil plus emulsifying agents. This is applied to previously swabbed, dried decks with new or clean swabs so that one gallon covers one

thousand square feet of deck space. The treated area must then be allowed to remain unoccupied for at least two hours. This procedure should be repeated once weekly for the first three weeks and subsequently carried out at two-week intervals. If for any reason a portion of the deck requires washing, it should be re-oiled immediately. This procedure is satisfactory only on bare wood floors. It cannot be used on linoleum, concrete, terrazzo, and other finishes. A sweeping compound, 51-C-1617-500, Sweeping Compound, 150 to 200 lb. container, is recommended for use on all floors with these coverings.

(2) For blankets: The formula used is very similar to the deck oil emulsion except that the oil used for blankets is more highly refined. Fundamentally, "blanket oiling" is a simple procedure which is best carried out in a laundry. The oil emulsion is added to the final rinse water and the blankets rotated in the tumbler. Used blankets are first washed in lukewarm soap and water, with care being exercised to rinse out all soap from the blankets prior to the oiling process. No washing procedures are necessary prior to the impregnation of new blankets. To insure that shrinkage does not occur and that the quality of the blanket is not impaired, the wash and rinse water should be only lukewarm. During the final rinse, the blankets should be allowed to remain in the emulsifying solution for the shortest possible time; that is until the milkiness of the emulsion disappears. Following the oil impregnation, the excess water is removed from the blankets by spinning the blankets in the rotary dehydrator, after which they are dried in warm air. As washing removes a substantial amount of oil, all blankets should be re-oiled after each washing.

(c) Until better methods for control of bacteria are available for general use, common sense precautionary measures must be observed. As dust count and bacteria count are interdependent, efforts to clean barracks without producing heavy dust concentrations will go a long way toward control of infection. Dry sweeping or dusting of decks should, therefore, be avoided. Oiled sawdust which is provided by the Navy for this purpose should always be laid down before sweeping. The use of dry abrasives, as dry steel wool, for cleaning and polishing barracks floors should be discouraged; wet abrasives only should be used. Similarly, vigorous shaking of bedding should only be performed outside--never in the sleeping quarters.

(d) The use of a soap and water solution for swabbing down unoiled floors of oiling quarters is desirable. Swabbing down with soap and water should be done once or twice weekly in sleeping quarters and once or twice daily in the heads.

Chapter 3

Heating, Ventilation, and Air Conditioning of Ships

1. General.--Matters of material relating to heating, ventilation and air conditioning on shipboard come under the cognizance of the Air Conditioning Section of the Shipbuilding Division of the Bureau of Ships. But since these matters bear such an important relation to the well-being of all personnel afloat, it is important that members of the Navy Medical Department be familiar with the fundamentals of heating and ventilation so that they may interpret the results properly. The medical officer afloat must be able to define and recognize satisfactory air conditions, and, equally as important, must be able to define and recognize air conditions which will be prejudicial to the health of personnel. This means that the medical officer and members of his department must make basic air measurements in terms of temperature, humidity and air movement, and must record physiologic data in terms of pulse rate, body temperature and certain clearly defined subjective reactions. He must then evaluate this data and submit his findings to the engineer together with any specific recommendations he may have.

2. Purpose.--It is the purpose of this chapter to present the fundamentals of heating, ventilating and air conditioning, and to describe the physical and physiologic measurements which can be made on shipboard in order to evaluate the existing atmosphere in terms of its reaction on personnel.

3. The components by which any atmosphere can be fully described, dry bulb and wet bulb temperatures, wall surface temperature, moisture content or relative humidity, and air movement, are familiar to personnel of the Navy Medical Department. They are presented briefly here as reference material, for this chapter will deal largely with these properties.

4. Dry Bulb Temperature.--The dry bulb temperature of air is that temperature recorded by any ordinary thermometer the reservoir or bulb of which is dry and, therefore, not affected by the cooling effect of evaporation of moisture. When the layman speaks of the prevailing air temperature, which he reads from his standard mercury thermometer, he is speaking of the dry bulb temperature.

5. Moisture Content.--The atmosphere always contains a certain amount of moisture in the vapor state. The (dry bulb) temperature of the existing air directly affects the capacity of the air for containing evaporated moisture. Moisture content is usually expressed in terms of grains of moisture per pound of dry air.

6. Relative Humidity.--Relative humidity is the ratio of the amount of water vapor the air does contain under existing conditions to the amount of water vapor the air could contain at the same dry bulb temperature when saturated.

7. Wet Bulb Temperature.

(a) The wet bulb temperature, measured by a standard wet bulb thermometer, is that temperature which a thoroughly wet body will attain if the air passes over it for a sufficient length of time and with a high enough wind velocity. When wet and dry bulb temperature are the same, the air is said to be saturated (or relative humidity is 100%). If the dry bulb temperature is lowered below this saturation point, moisture condenses; in other words, it rains.

(b) In practice a sling psychrometer, mounting a wet and dry bulb thermometer side by side, is used to determine these two temperatures. The relative humidity can then be determined directly from the psychrometric chart. Fig. 3-1 shows not merely the relative humidity, but also the comfort zone in "still" air.

8. Air Movement.--Air movement, applied to heating and ventilating of rooms, refers to turbulent air currents at any given point in a room. It is usually expressed in feet per minute (f.p.m.).

9. Effective temperature is a consideration of basic importance to the subject of naval ventilation. Its applications as well as its limitations should be thoroughly understood.

10. Significance of Effective Temperature.

(a) Effective temperature is an index which combines into a single value the thermal effect of temperature, humidity and movement of air upon the human body. By repeated experiments, the subjective response by groups of individuals to variations of temperature and humidity in still and moving air was studied. A series of different temperatures and humidities which produced the same feeling of warmth or coldness were taken as having the same effective temperature. Effective temperature lines may be included on the psychrometric chart.

(b) Effective temperature is an index, or series of humidity-temperature conditions, rather than a quantitative measurement. In order to identify a given effective temperature series, the corresponding saturation temperature is used. Thus an effective temperature of 80° (written 80° E. T.) is that series of humidity and temperature conditions all of which impart the same feeling of warmth to the body as does air at 80° F. and 100% relative humidity. Increasing the movement of air reduces effective temperature. For example, 75° E.T. in still air corresponds with 71.5° E.T. in air moving at a rate of 300 f.p.m.

(c) The foregoing facts would lead to the conclusion that conditions of comfort may be realized by varying one or two of the effective temperature components independently of the others, or by varying all together. Within practical limitations this is true, but these limitations must be given full recognition.

11. Limitations of effective Temperature Charts.

(a) Effective temperature charts, can be applied only under conditions duplicating those under which the data for the chart were assembled. Air velocities must be approximately the same. Weight of clothing and degree of activity must be about as specified. Most important, since these charts deliberately omit radiant heat as a factor, a correction must be applied. Under ordinary air conditions, each degree of elevation or depression in the mean "wall" surface temperature (weighted mean temperature of bulkheads, glass, overheads, and decks) above or below the air temperature requires about 0.5° counterchange in the effective temperature.

(b) Although there are no effective temperature charts available for conditions in which radiant heat is a factor, it should be borne in mind that the principle of effective temp-

erature remains valid under these conditions when proper correction for radiant heat is made.

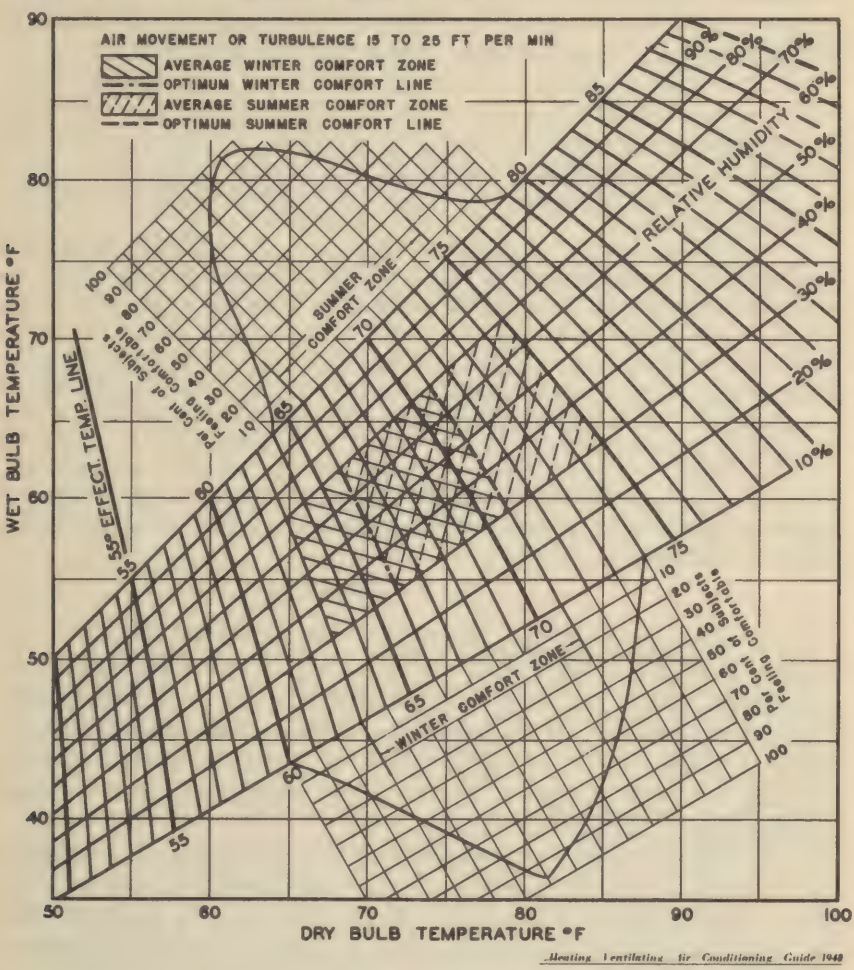

FIGURE 3-1.--COMFORT CHART FOR AIR VELOCITIES OF 15 TO 25 FPM (STILL AIR).

NOTE.--BOTH SUMMER AND WINTER COMFORT ZONES APPLY TO INHABITANTS OF THE UNITED STATES ONLY. APPLICATION OF WINTER COMFORT LINE IS FURTHER LIMITED TO ROOMS HEATED BY CENTRAL STATION SYSTEMS OF THE CONVECTION TYPE. THE LINE DOES NOT APPLY TO ROOMS HEATED BY RADIANT METHODS. APPLICATION OF SUMMER COMFORT LINE IS LIMITED TO HOMES, OFFICES, AND THE LIKE, WHERE THE OCCUPANTS BECOME FULLY ADAPTED TO THE ARTIFICIAL AIR CONDITIONS. THE LINE DOES NOT APPLY TO THEATERS, DEPARTMENT STORES, AND THE LIKE WHERE THE EXPOSURE IS LESS THAN 3 HOURS. (FROM HEATING, VENTILATING, AIR CONDITIONING GUIDE, 1948 ED., PUBLISHED BY THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

12. Objectives of Heating, Ventilating and Air Conditioning Afloat.--In the section of the Bureau of Ships Manual devoted to this subject the following objectives are described:

The weight added the space occupied, and the power consumed by the ventilation, heating and cooling arrangements on a naval vessel must be at the expense of other military necessities.

The minimum of equipment is provided which will accomplish the following purposes:

(a) To maintain, in the living spaces and normally occupied parts of the vessel, conditions which will keep personnel fit to fight under the strain of frequent watches during prolonged wartime cruising.

(b) To maintain at battle stations and in working spaces conditions which will keep personnel physically fit to fight and mentally keen under the circumstances when such spaces must be occupied during war.

(c) To maintain in certain spaces containing equipment or material the conditions necessitated by the presence of that equipment or material.

Basically the environment must be such that the body can maintain a proper heat balance and the chemical composition of the air must be such that it contains no harmful components and provides a sufficient quantity of oxygen.

13. Elements of the Problem.--In order to evaluate the degree of success achieved aboard ship in meeting the basic physiologic requirements summarized in the final paragraph of these objectives, it is desirable that members of the Navy Medical Department be familiar with certain considerations entering into the design of the heating, ventilating and cooling arrangements on naval vessels.

(a) When designing a heating or ventilating system ashore the climatic conditions of the locale can be anticipated and the system designed accordingly. This obviously is not the case for naval vessels for which the heating and ventilating systems must be designed to provide for climatic conditions ranging from the Arctic in winter to the Tropics in summer. A wide range of flexibility is, therefore, required of the heating and ventilating arrangements aboard ship.

(b) Space, weight and power requirements are important governing factors in the design and specification of ventilation and heating equipment. It is also essential to preserve the structural integrity of the ship, and penetrations of the main watertight structure must be kept at an absolute minimum. In spite of this, fresh air or heat must be provided to various compartments often far removed from the source of supply.

(c) The design is further complicated by the lack of uniformity of ventilation or heat demands throughout the ship.

Spaces exposed on one or more sides to the weather are subject to the influences of the existing weather conditions, which may cause high rates of heat gain or loss. Inside spaces may be subject to the effects of so called "wild heat" that is, uncontrolled or waste heat from machinery, boilers, galley stoves, etc. Thus it may be that two compartments separated perhaps only by a passageway, one may require heating and at the same time the other may require cooling. Naval heating and ventilating, therefore, presents the complex problem of providing a minimum of equipment to take care of a maximum range of conditions.

14. Heating.--Heating aboard ship is accomplished by drawing fresh outside air over steam coils and discharging the heated air into the various compartments. Outside air is preheated (i.e.: before passing through the fan) to 40° to 60° F. in order to provide greater over-all flexibility of the heating system, and in order to avoid condensation of moisture on the air ducts. The air is reheated to the desired delivery temperature for a given zone prior to distribution to the various compartments and spaces within that zone. Each zone is comprised of a group of adjacent spaces all of which have approximately the same heat demands.

15. Ventilating.

(a) Ventilation aboard ship during hot weather serves a dual purpose--cooling and replenishment of vitiated air.

(b) Cooling by ventilation is a process of diluting inside air with outside air. It is evident, therefore, that it is not possible to cool a space by dilution to a temperature lower than that of the outside air. And since there are sources of heat within the ship--personnel, lights, and machinery--it follows that within the practical limitations of ventilation by dilution it is not possible to cool the space as low as the temperature of the outside air. It is analogous to running both hot and cold water simultaneously into a bucket. The temperature of the mixture can never reach that of the cold water itself. BuShips working standard for living spaces is sufficient air to maintain the dry bulb temperature not more than 7 degrees higher than the weather air, but at least 30 cubic feet per minute per man.

(c) Various sources of moisture exist within the ship. Personnel are a constant source of added moisture--a man at light work gives off 1,500 grains of moisture per hour when the temperature is 85° D.B. for example. In addition, there are various machines and operations which add moisture to the atmosphere. Consequently the moisture content of air in

living and working spaces will never be less than that of outside air.

(d) Mechanical supply and exhaust are provided for most working and living spaces and the quantity of each is balanced within the respective major sections of the ship. Those compartments such as galley, laundry, heads, etc., which produce heat or undesirable odors are provided with a greater volume of mechanical exhaust than supply, designed to maintain an induced air flow to the compartment and thus prevent the spread of heat or odors to adjacent spaces. Compartments used for living, berthing, etc., are provided with a greater volume of mechanical supply than exhaust, designed to maintain an induced air flow out of the space and thus prevent the entrance of possibly contaminated air from adjacent spaces.

(e) The fireroom and machinery space require a special application of cooling with outside air. The machinery of these spaces produces so much "wild heat" that it would be literally impossible to reduce the temperature of the entire space to that of a good working atmosphere. This being the case, spot cooling is provided personnel on duty. By this method, air is supplied at high velocity from ventilation ducts concentrating their discharge at the respective watchstanders' stations. Although the ambient air temperature may be very high, the space in the immediate vicinity of the watchstander in this manner will be maintained within the range of acceptability.

(f) The need for maintaining the ventilation system clean cannot be overemphasized. It has been estimated that a large naval vessel may take into the ventilation system as much as five tons of dirt in a day. Although most of this is fine, particulate matter, and, therefore, is carried through, a part of this dirt remains in the screens, heaters, fans, cooling coils, and ducts. As this material accumulates in the system, the capacity of the system for delivering air is reduced, ultimately seriously so. For this reason, cleaning schedule for all parts of the ventilation system, particularly for screens, heaters, and cooling coils, should be established for all ships.

16. Air Conditioning.

(a) Air conditioning as applied ashore is a broad term, covering the field of heating and ventilating in all its phases. In this chapter the term "air conditioning" is intended to mean temperature and humidity control of air.

(b) Mechanical cooling and dehumidification of air aboard naval vessels is accomplished by passing air through coils containing a suitable cooling agent, or refrigerant. The cooling coils may be located in an intake air duct with the refrigerating

machinery located some distance away; or the refrigeration machinery, cooling coils, and circulating fan may be assembled into a single unit. Air, in passing through the cooling coils, gives up heat (to the refrigerant) and moisture (by condensation) and is delivered to the compartment suitably conditioned.

(c) Air conditioning aboard naval vessels has many applications not directly concerned with personnel. Certain work shops, laboratory spaces, and compartments containing precision instruments may require temperature or humidity control, or both.

(d) Except for selected living spaces of newer vessels, air conditioning within the meaning of this chapter has not yet come into general use for living spaces aboard naval vessels. Hospital ships are an exception, for on such ships space and weight factors are less critical and personal comfort of patients and crew assumes greater importance.

Section IV.--PHYSIOLOGIC PRINCIPLES

17. Effects of Air Movement.

(a) A certain amount of air movement is desirable. In still air the body is enveloped by a layer of warm, moist air, resulting from body heat and evaporation of perspiration. A controlled air movement removes this layer and adds greatly to the feeling of comfort.

(b) The maximum air velocity which can be tolerated comfortably by the human body in warm atmospheres has been established by test to be about 100 to 125 f.p.m. In cool weather good practice generally limits maximum air movement to not over 50 f.p.m. Air blowing at high velocities from the overhead onto the heads of occupants is undesirable except in hot atmospheres. Similarly, an air stream directed against the back and neck becomes uncomfortable.

18. Effects of Heat.

(a) As an introduction to this subject it would be desirable to restate for emphasis two practical limitations of hot weather cooling by ventilation aboard ship.

(1) There are sources of added heat within the ship. Therefore, it is not possible to bring the temperature of the air inside the ship to a temperature as low as that of the weather.

(2) There are sources of added moisture within the ship. Therefore, the moisture content of the inside air will always be higher than that of the outside air.

(b) In view of these limiting factors, ventilation rates for hot weather cooling of a given space are always designed to limit the temperature rise of that space to a predetermined amount, using the highest anticipated hot weather (outside) temperature as a basc. This highest hot weather temperature is taken as 88 ° F.D.B. (Fahrenheit Dry Bulb), and for berthing spaces, for example, the maximum temperature rise upon which ventilation rates are based is from 7 ° F. to 10 ° F. No reference is made to the relative humidity in these calculations since no control over it is possible by ventilation alone.

(c) The physiologic aspects of naval ventilation can be evaluated more readily if the foregoing basic limitations are kept in mind.

(d) The body eliminates waste heat by three means:

(1) By radiation to cooler objects.

(2) By convection--that is, by losing heat to the air as it comes in contact with the body.

(3) By evaporation of perspiration from the surface of the skin and by moisture lost in exhaled air.

(e) The existing atmosphere obviously has a great influence on the manner in which these various heat regulating processes function at any given time. Discounting the effect of radiation, which is an environmental, not atmospheric, consideration and which is therefore wholly unpredictable, the following three examples will serve to illustrate the influence of the atmosphere.

(f) If the dry bulb temperature of the air is 80 ° F., relative humidity 30%, and air movement moderate, all heat eliminating mechanisms are able to function and the suitably dressed individual feels comfortable.

(g) If the air temperature is raised to 99 ° F.D.B., and the relative humidity is 30%, and moderate to high air movement exists, no body heat is lost by convection, but an adequate amount of cooling will take place by evaporation of perspiration, and through exhaled moisture. If the air is still or moving slowly, evaporation of perspiration will be so reduced as to result in serious distress from the heat.

(h) If, however, the air temperature is 99 ° F.D.B. and the air is saturated (100% relative humidity), since the air can take up no additional moisture, and air and body temperature are equal, all means of heat elimination are denied the individual, and the body heat regulating mechanism ultimately will fail.

(i) When the body heat regulating mechanism fails, part of the heat is retained in the body, causing a rise in skin and deep tissue temperature, an increase in heart rate, and accelerated respiration. The metabolic rate also increases owing to the excessive rise in body temperature, and in extreme conditions a vicious cycle may result which eventually leads to serious physiologic damage.

19. Acute Overheating.

(a) Acute overheating leads to four syndromes: heat stroke, heat exhaustion, super-dehydration, and heat cramps.

(b) The exact mechanism underlying the production of heat stroke is not well understood. Patients in a hypertherm chamber develop artificial fever, but with free perspiration and without the other evidences of heat stroke. In typical heat stroke, on the other hand, cessation of perspiration seems to be one of the very early signs of trouble. It seems possible to segregate individuals into two classes - those susceptible to heat stroke and those not susceptible to heat stroke. There is some evidence indicating that individuals not susceptible to heat stroke will continue to perspire freely to the end, whereas individuals susceptible to heat stroke exhibit an impaired ability to sweat.

(c) Heat exhaustion or circulatory insufficiency, while still a direct result of difficulty in dissipation of body heat, differs sharply from heat stroke. In the latter condition there is fever and delirium, with full bounding pulse and elevated blood pressure, while the skin is flushed and dry. Immediately important in therapy is rapid heat removal by the best means at hand. Heat exhaustion, on the other hand, is characterized by subnormal body temperature, cold, pale, clammy skin, low blood pressure and a state of circulatory shock. Here immediate treatment should be directed toward raising the body temperature to normal, improving the tone of the vascular system and allaying hyperactivity in the digestive musculature. Administration of salt solution by mouth or vein is indicated.

(d) Of great importance is the physiologic consideration of the shift in blood from the internal organs to the periphery. The dilation of the blood vessels of the skin and the abnormal distribution of blood to the skin area, merely for the purpose of cooling the body, place a heavy load on the cardiovascular system. This shift in blood, moreover, may explain the prevalence of gastro-intestinal disorders in hot weather.

(e) A practical precept is that individuals in hot environments must be allowed to sit down periodically to relieve the excessive cardiovascular strain. Otherwise, the common

complaint and the factor that limits endurance is tired, swollen feet

(f) Knowledge is lacking as to why one individual develops the dynamic hyperpyrexia response and another the hypothermic shock reaction. Unfortunately, one experience with either type of excessive heat reaction predisposes the patient to subsequent attacks and to troublesome prodromal symptoms with exposure to external heat of relatively low order. So far no means have been discovered for overcoming this increased sensitivity induced by a preceding heat attack. Careful avoidance of exposure for the next several years remains the only safe course for the patient to follow Selection of personnel and gradual adaptation to heat will help to reduce the incidence of heat stroke.

(g) Super-dehydration is an excessive loss of water as sweat without adequate replacement. The essential phenomena are thirst, reduced salivation, oliguria (elevated blood pH), acidaemia, dyspnoea, exhaustion, normal temperature, concentration of blood, shriveled skin and sunken eyes.

(h) Heat cramps, in the skeletal muscles, bear little relation either to heat stroke or heat exhaustion. The cramps are due primarily to excessive salt loss during profuse and prolonged perspiration without adequate salt intake. Relief is readily obtained by adding ordinary table salt to the drinking water, or taking it in any other convenient form. Sometimes a patient suffering from heat exhaustion will also be suffering from skeletal muscle cramps, but usually the conditions are not associated. Laborers in desert heat and in boiler or furnace rooms are particularly prone to heat cramps because of their excessive perspiration and rapid salt loss.

20. Salt, Salt Solutions, Fluids, and Vitamin C Requirements.

(a) Salt loss through the skin as a result of sweating is of the order of 0.1 to 0.5 percent depending upon acclimatization. During a period of twenty-four hours, four to eight quarts of fluid and four to eight grams of salt, equivalent to one or two teaspoons of salt may be lost in this manner.

(b) Replenishment of this quantity of salt is best obtained, not through the ingestion of salt tablets, but by greater ingestion of salt at mealtime or by adding salt to the drinking water to make a solution of not more than 0.10 percent salt. The salinity of this solution for cold water is not objectionable.

(c) If small quantities of salt are not added to the drinking water, the serving of soup or tomato juice will take care of the problem, which is essentially the replacement of salt lost through the skin.

(d) A bouillon cube containing two grams of salt, dissolved in a pint of water, twice daily will usually meet the additional salt requirements.

(e) Studies indicating that vitamin C may also be excreted in sweat have been reported, and the addition of vitamin C to the diet accordingly may be desirable. Mills has further stated that additional vitamin B, thiamin hydrochloride, is beneficial in hot atmosphere.

21. <u>Control of Heat.</u>

(a) Naval ventilation is designed to prevent not only the existence of conditions aboard ship which could lead to acute overheating, but is designed to maintain an atmosphere conducive to physical efficiency of personnel.

(b) The upper limit of desired air conditions are based upon shipboard test. The effective temperature range of 69° E.T. to 75° E.T. will be associated with heat loss from the body without visible sweating. In men at rest, about 60 to 80 percent of body heat loss will be brought about by radiation and convection, and 20 to 40 percent by the evaporation of insensible perspiration. If the ventilation system succeeds in eliminating visible sweating of personnel at rest, it is fulfilling one of the most important purposes for which it was designed. Moisture lost from the body by sweat which runs off as liquid does not represent a heat loss, for it is the latent heat of evaporation which brings the cooling effect to the body surface.

(c) While the range of 69° E.T. to 75° E.T. represents the upper limits of air conditions desired for comfort, it is apparent from an understanding of the practical limitations of ventilation that the desired effective temperature cannot always be maintained. As a practical measure, therefore, an understanding should be gained of what air environment can be tolerated. In arriving at an upper limit of tolerance, it must be recognized that the dividing line between atmospheric conditions which can be tolerated and those which cannot be tolerated is not clear-cut. Kind and amount of clothing will influence the selection. Bracket fans will increase air movement. Men acquire a degree of acclimatization to tropic weather These factors tend to raise the maximum effective temperature which can be tolerated.

(d) The following observations may be taken as an average:

(1) An effective temperature of about 86° F. is the upper limit at which heat balance can be maintained at rest without a rise in body temperature.

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(2) An effective temperature of 91° F. is an upper limit in compartments deprived of spot cooling for men exposed during a four hour watch. A rise in body temperature and an increase in pulse rate will occur, even during the resting state.

(3) As a result of long experience in mining operations in South Africa, it is considered that 93° F. in air saturated with moisture, hence 93°F. effective temperature is a critical level above which many cases of heat prostration occur.

22. Effects of Cold.

(a) The initial responses to cold are indicative of stimulation of the sympathetic nervous system to produce shivering and finally a secretion of adrenin which gives rise to constriction of blood vessels, increased heart rate and blood pressure, hyperglycemia, and increase in metabolism. There is also evidence that the thyroid gland enlarges in response to stimulation by cold. These reactions tend to be beneficial to the healthy individual but harmful to the unfit.

(b) The harmful effects of chilling are manifest in individuals hypersensitive to cold, and in persons susceptible to respiratory infections. Some individuals, for example, exposed to cold water or air may exhibit urticaria and syncope, symptoms indicative of the liberation of abnormal amounts of histamine in the skin.

(c) There is good evidence showing that exposure to cold and to changes in temperature lower the resistance of animals to infection, apparently by depressing their defensive mechanism. The prevalence of respiratory diseases in cold weather is attributed partly to the lowered resistance of the mucous membranes of the nose and throat, which results from the vasomotor shifts of blood in the internal organs. Keyser believes that the lowered resistance is due to a diminution in the number and phagocytic activity of the leucocytes (white blood cells) brought about by exposure to cold and to changes in temperature.

(d) On exposure to cold, the loss of heat is increased considerably, and only within certain limits is compensation possible by increased heat production and diversion of blood to the internal organs. The blood pressure rises owing to constriction of the peripheral vessels and to concentration of the blood. The skin, subcutaneous tissues, and muscles form reservoirs for storing the water which leaves the blood. In extremely cold atmospheres, the protective responses fail, and

death may follow when the body temperature (rectal) falls to about 80° F., although in hypothermia, Talbott reports rectal temperatures of 72° F., with complete recovery and others have reported similar values in severe alcoholism.

(e) The effects of cold are first exhibited by a painful vasoconstriction and cyanosis followed by a reactive hyperemia, normal color, and cessation of pain.

(f) The feet, representing a dependent part of the body possessing the poorest circulation, usually show the complications of exposure to extreme cold, or to a more moderate degree of cold if prolonged and "wet", which give rise to such terms as "trench foot" and "immersion foot."

(g) In the case of chilling without actual frostbite, i.e. killing of tissues, the parts involved often become edematous on being warmed up. There can be no doubt that the easiest way to reduce the edema of chilling consists in alternating cold and heat quite rapidly. Therefore, heat should not be applied to an area of the body affected by cold.

(h) From the practical viewpoint of naval ventilation, less emphasis need be placed upon the effects of prolonged exposure to sub-freezing temperatures than upon the physiologic effects upon men who are repeatedly subjected to a sudden and extreme change of temperature as they come from heated compartments to sub-freezing topside weather. The injury is increased if the compartment contains a dry, hot atmosphere, which is conducive to injury of the membranous nasopharynx, especially upon subsequent exposure to cold air.

(i) Catarrhal fever, acute and chronic tonsillitis, and influenza grouped together comprise thirty percent of all admissions, and 11.5 percent of total sick days. Apart from overcrowding, the effect of rapid changes in environmental temperatures is a paramount predisposing cause in this type of infection.

23. Heating of Cold Air.

(a) The Bureau of Ships, recognizing the problem, endeavors to make some compensation for it in their designs for cold weather heating. In their "Instructions for Heating of Spaces on Naval Vessels" the Bureau of Ships Tentative Ventilation Standards state:

> An appreciable physiological strain is caused by going from an overheated compartment to below freezing topside temperatures. During cold weather it is much better to maintain living space temperatures at the minimum consistent with comfort.

(b) During cold weather, therefore, living spaces aboard ships are designed to be maintained at 70 ° F.D.B. Inside working spaces are heated to a lower temperature which will be in keeping with the degree of physical exertion the work demands. Keeping in mind that these temperatures are designed to be the "minimum consistent with comfort," it will be to the best interests of all if individual demands for adjustment in temperature be met by adding or removing outer clothing.

(c) It has been described previously in this chapter that for all normal applications heating of compartments in cold weather is accomplished by heating the air delivered (at a reduced rate) by the ventilation system. The amount of heat supplied is designed to balance heat lost when the outside weather temperature is 10 ° F. and sea temperature, 35 ° F. --the lowest anticipated temperatures for air and sea respectively.

(d) It will be seen from the pyschrometric chart that the moisture content of cold air is very low. Saturated air at 10 ° F. contains only 9 grains of moisture per lb. of dry air, whereas the corresponding value for saturated air at 80 ° F. is 155 grains. This characteristic presents a contrast between summer and winter ventilation which bears consideration. The relative humidity of incoming air during summer ventilation is the same as that of the weather. The relative humidity of incoming air during winter ventilation on the other hand is considerably lower, after heating, than the weather air. For example, if the temperature of weather air at 10 ° F.D.B. and 70% relative humidity is raised to 70 ° F.D.B. without any moisture being added or removed, the relative humidity will be 5 % upon delivery to the compartment.

Section V.--ATMOSPHERIC DEFICIENCIES AND CONTAMINANTS

24. Oxygen deficiency in closed spaces.

(a) In spite of the continual emphasis which has been placed upon the existence of this hazard, fatal accidents are still occurring afloat either from failure to recognize this danger or to take adequate precautions against it.

(b) Notice the suddenness with which the following multiple tragedy occurred on a battleship at sea early in 1944:

> Three deaths resulted from entering a space on the sixth deck below, which had not been previously ventilated. The air in this space was known to be foul and the first man to enter did so to install a blower for ventilation purposes. Before he could get the blower into operation he succumbed to the lack of oxygen and what was later determined to be a

very high percentage of carbon dioxide (between 7 and 8 percent). The other two were overcome attempting to aid the first. The men were removed by workers using rescue breathing apparatus but not before they had been unconscious for from ten to fifteen minutes. Artificial respiration and all other resuscitory measures were without avail. (From the report of the senior medical officer)

(c) The report reveals that in this case a deficiency of oxygen was suspected, and precautions were being taken to remedy the deficiency. Unfortunately the precautions were inadequate.

(d) All void spaces, storage tanks, all closed storerooms (particularly those containing fresh fruit or vegetables), and storerooms in which the ventilation has been shut down for a day or more, should always be considered as potentially deficient in oxygen.

(e) Whenever oxygen lack is suspected, the following precautions must always be observed.

(1) Provide ladders where holds or compartments must be entered from the deck above.

(2) Provide thorough ventilation before entering the compartment.

(3) Provide a life line for all persons entering the compartment.

(4) Whenever personnel enter any compartment where there is known or suspected to be a noxious gas (or lack of oxygen) they must wear a self-contained oxygen breathing apparatus. Do not substitute a different type respirator.

(f) Of frequent occurrence is the fatal error of entering closed compartments without taking the third and fourth simple, precautionary measures.

25. Carbon Dioxide.--Variations in carbon dioxide content of the atmosphere, except in the cases of closed or unventilated compartments, have little or no significance in ventilation afloat or ashore. Even very low rates of room ventilation will serve to supply oxygen needs and eliminate carbon dioxide, provided there is no source of contamination other than the individual.

26. Carbon Monoxide.

(a) Carbon monoxide can exist in dangerously high concentrations as a result of fires, or as a result of careless use of portable or mobile gasoline combustion engines.

(b) Ventilation rates have been carefully planned for tank and vehicle carrying craft to control the maximum anticipated

carbon monoxide exposures when the engines of all tanks and vehicles are operating. Hanger deck spaces of aircraft carriers are similarly provided with adequate ventilation to maintain within safe limits the concentration of carbon monoxide.

(c) The following table will serve as an approximate method of anticipating the effects of exposure to varying concentrations of carbon monoxide:

Time of Exposure v. Concentration Rule:

(1) Time of exposure in hours multiplied by the concentration in parts per 10,000 equals 3 (no perceptible effect).

(2) Time of exposure in hours multiplied by the concentration in parts per 10,000 equals 6 (just perceptible effect).

(3) Time of exposure in hours multiplied by the concentration in parts per 10,000 equals 9 (headache and nausea).

(4) Time of exposure in hours multiplied by the concentration in parts per 10,000 equals 15 (dangerous to life).

(d) In the Hudson River tunnels, for example, a concentration of 4 parts of carbon monoxide per 10,000 is permissible for a truck passing through in 45 minutes. This means 4 multiplied by 0.75 or 3, a concentration devoid of annoyance to the driver.

(e) Symptoms in Relation to Concentration of Carbon Monoxide:

	Effect
(1) 0.01 percent or 1 part in 10,000	No symptoms for 2 hours.
(2) 0.04 percent or 4 parts in 10,000	No symptoms for 1 hour.
(3) 0.06 to 0.07 percent or 6 to 7 parts in 10,000	Headache and unpleasant symptoms in 1 hour.
(4) 0.10 to 0.12 percent or 10 to 12 parts in 10,000	Dangerous after 1 hour.
(5) 0.35 percent or 35 parts in 10,000	Fatal in less than 1 hour.

27. Bacteria.

(a) Living pathogenic micro-organisms, which may exist in the atmosphere, must be controlled principally by ventilation. It has been demonstrated that droplets produced from sneezing, coughing, spitting, etc., if of sufficiently small size (under 0.1 mm diameter) will be evaporated before settling to the

floor. The nuclear residue may persist in the atmosphere for an indefinite time thereafter, and may represent a source of infection to other people. (See para. 2-16).

(b) Methods for sterilization of air are not yet available as a practical defense measure against this possible source of air-borne infection. (See para. 2-17).

28. Odors.

(a) The physiologic effect of odors given off by human bodies, and by various organic processes and substances, is not clearly defined. There is reasonably clear evidence that such odors bear an influence upon appetite, and as such they are of real hygienic significance. Man has an acute ability to detect odors in concentrations so small as to be immeasurable by chemical or physical means. Attempts to filter unpleasant odors, or to mask them by substitution of a more agreeable odor, have met with only partial success.

(b) However, whether the effect of disagreeable odors is physiological or esthetic, the fact remains that odors do result in decreased appetite, and a disinclination to physical activity. Ventilation rates to eliminate odors from berthing and living quarters are considerably in excess of those required to supply oxygen and eliminate carbon dioxide.

29. Tobacco Smoke.

(a) Tobacco smoke constitutes one of our most difficult problems, particularly in sealed spaces in ships and in the submerged submarine where the air is recirculated.

(b) The effects of smoke are due to the nicotine absorbed by the body, the odors particularly of stale smoke, and to irritation of the eyes and respiratory tract. The presence of appreciable amounts of carbon monoxide accompanying the smoke has been under investigation. Without discussing the familiar toxic symptoms of salivation, nausea, impending sweat, and a feeling of exhaustion and palpitation, it should be pointed out that tolerance for tobacco varies greatly, and that young individuals are more susceptible than adults. Some individuals appear to be allergic to tobacco smoke.

(c) Although the acquisition of tolerance protects against unpleasant symptoms within limits, it is certain that the smoke in the rebreathed air of the enclosed spaces will exert its full harmful effect upon personnel not habituated to the usage of tobacco. It follows that under these conditions the usage of tobacco is to be interdicted.

(d) Apart from its inherently toxic effect, tobacco smoke, by virtue of its accelerative influence on pulse rate, acts as a complicating variable to confuse estimates of cardiovascular

fitness and response to deleterious environment expressed in terms of pulse rate.

Section VI.--EVALUATION OF SHIPBOARD ATMOSPHERE

30. Physical Measurements.

(a) While Medical Department personnel need not attempt to describe in detail the physical characteristics of the prevailing shipboard atmosphere, nevertheless in order to evaluate properly the ventilation aboard ship in terms of its physiologic effects, certain minimum physical measurements are necessary. Comments relative to ship's ventilation in the Annual Sanitary Reports should always be based on these physical data, or much of the value of this section of the A.S.R. is lost.

(b) In offering constructive criticism on ventilation, the compartment or section of the ship about which the comments are concerned should be identified in the following manner:

(1) Compartment name and number.
(2) Approximate location.
(3) Approximate dimensions.
(4) Principal use of compartment.
(5) Average number persons occupying compartment.
(6) Other relevant data such as heat producing machinery. within compartment, adjacent hot spaces, etc.

(c) The ventilation system of the compartment in question should be described briefly with the following information supplied:

(1) Is mechanical or natural ventilation used for air supply? Exhaust?
(2) If the information is available give the total volume of air supplied to or exhausted from the compartment.
(3) Number of bracket fans installed.

(d) The following physical measurements can be made very readily and should be reported:

(1) Sea water temperature, F.
(2) Dry bulb temperature of weather, °F.
(3) Dry bulb temperature of compartment, average °F.
(4) Dry bulb temperature at supply terminals, °F.
(5) Dry bulb temperature at exhaust terminals, °F.
(6) Wet bulb temperature of weather and compartment air °F. (when psychrometer is available aboard ship).

31. Physiologic Measurements.--The symptoms of subacute conditions arising out of continued exposure to elevated temperatures and humidities are not uniform or readily classifiable. This factor makes it very difficult to determine on a physiologic basis the atmospheric end-point of adaptability or tolerance. The following observations have been suggested as an aid in evaluating physiologic response to elevated temperatures:

(a) Oral Temperature: On the basis of experience, an average group rise of 0.5° and an individual rise of 1.5° in oral temperature may be arbitrarily assigned as values limiting further exposure. Some tests indicate that the body temperature will reach 100.5° F. in 2 hours at 93° E.T., in 1 hour at 95° E.T. and in 1/2 hour at 99° E.T.

(b) Pulse Rate: As an upper limit for pulse rate of men engaged in light activity in hot environments, an arbitrary limit of 140 has been set. This limit permits a narrow margin of safety since an increase in pulse rate to limits approaching 170 or 180 frequently precedes collapse.

(c) Foot Shoe Temperature: (measured by inserting a thermometer in the shoe so that the bulb rests under instep). This value serves primarily as an index to physical comfort. The temperature range between 60° F. and 100° F. is regarded as the comfort zone. For extreme environmental temperatures, suitable (temporary) insulation of the deck will assist a watchstander to maintain a comfortable foot-shoe temperature by reducing the conduction of heat away from or to the feet, as the case may be.

(d) Subjective Response: In view of the many variables which enter into individual reactions to a given environment, subjective response is of only limited value, but may serve to confirm other observed data. A fixed sensation scale using the terms: cold, comfortably cool, comfortable, comfortably warm, and hot, will aid in arriving at an evaluation of existing conditions.

(e) Ultimate evaluation of the degree of success of ventilation and air conditioning aboard ship must be based on readily recognizable and positive physiologic data. To this end the prevelance of "prickly heat," fungus infections and their complications, weight loss, and undue fatigue among personnel should be reported. While it is recognized that high temperatures are not necessarily the cause of these conditions, high temperatures are, nevertheless, a contributing factor.

Chapter 4

Swimming Pools and Bathing Places

1. General Scope and Principles of Bathing Place Sanitation.

(a) Purpose.--This chapter is concerned with providing a summary of vital points necessary for proper operation, maintenance of equipment, and supervision of swimming pools and bathing places; the essential requirements for the protection of personnel using such facilities; and to effectively control the spread of disease in waters used for swimming.

(b) Responsibilities.--The operation and maintenance of Navy swimming pools is a function of the Public Works Department or Maintenance Department. The medical officer or his representative makes inspections and recommendations pertaining to the features of operation or maintenance which affect the health or safety of the swimmers.

Sanitary engineers attached to District Public Works Offices are usually available for consultation on special problems of operation. Public Works Department laboratories are usually available for making chemical and bacteriological tests of swimming water. Public Health laboratories are also available in most localities and their assistance should be requested if needed to supplement Navy laboratory work. .

No matter how well a public swimming pool may be constructed, it will not be safe from a public health standpoint unless the pool water is maintained absolutely free from disease-producing organisms at all times. Safety is likewise dependent upon the chemical and physical condition of the water; chemicals used in water treatment must be carefully controlled to prevent irritation of swimmers' eyes and nasal passages, and the water

must be kept clear to provide safety from drowning. The chemical and physical condition of the water, features of construction of the pool, and equipment, also have a direct bearing on the efficiency of disinfection.

(c) Classification of bathing places.--Bathing places may be divided into three classes:

(1) Natural outdoor ponds, rivers, tidal waters, etc.

(2) Outdoor pools which are partly artificial and partly natural in character.

(3) Pools, outdoor or indoor, which are entirely of artificial construction.

(d) In the control of swimming pool and bathing place sanitation, certain broad principles apply to all classes of bathing places:

(1) The same standards of cleanliness and bacterial purity of the water and the same provisions against the spread of disease apply at both indoor and outdoor swimming pools.

(2) The requirements are the same for all artificial and semiartificial pools, whether located indoors or outdoors, so far as the features of design and equipment apply to maintenance of cleanliness of the pool and the water with which it is filled.

(3) At public bathing beaches on natural waters the same sanitary standards should apply to bathing houses, dressing rooms, toilet facilities, and to the handling and care of bathing suits, towels, and other articles of bathing apparel as would be required at artificial swimming pools.

(4) Sanitary drinking fountains with a supply of pure water should be installed at all bathing places. The common use of towels, drinking cups, combs, hair brushes, or other toilet articles should be strictly prohibited.

Section I.--STANDARDS FOR DESIGN AND EQUIPMENT OF SWIMMING POOLS

2. Location, Design and Construction Features.--Details concerning these features will be found in the "Circular on Water Supply and Sanitation," NAVDOCKS P-147 dated 25 March 1945 (or the latest revision) which uses, as authority, the recommendations contained in the latest publication of the American Public Health Association's pamphlet on Design, Equipment, and Operation of Swimming Pools and Other Bathing Places. The scope of

the necessary information concerning location, design, and construction features is contained in the previously mentioned publications and includes:

(a) Location of swimming areas.

(b) Material, details of design, depth, proportion of deep and shallow ends, slope of bottom, side walls, pool lining and markings.

(c) Proportions of pool area to expected loads.

(d) Details of inlets and outlets.

(e) Runways and sidewalks.

(f) Steps, ladders, and step holes.

(g) Visitors' galleries.

(h) Dressing rooms.

(i) Showers, toilets, and lavatories.

(j) Lighting, heating, and ventilation.

(k) Recirculating systems.

(l) Pumps, hair catchers, piping systems, and cross connections.

(m) Proportioning of the water interchange for recirculation and flowing through pools.

(n) Filtration equipment.

Section II.--OPERATION

3. Factors in Maintaining a Safe and Attractive Swimming Pool.--The three main factors in maintaining safe and attractive pool water are disinfection, filtration, and the control of pH (acidity-alkalinity balance). These factors will be discussed in some detail, as most of the swimming pool operator's (and consequently, the medical officer's) troubles are concerned with them.

4. Disinfection.

(a) Purpose.--Infectious material in swimming pools usually originates from two sources: (1) from a polluted water supply, and (2) from infected persons using the pool. The first source can be avoided by strict attention to the choice and protection of the water supply. The second source, however, (the presence of infected persons in the pool) is an ever-present and serious hazard. Even with conscientious inspection of the swimmers there will always be some with incipient infection or communicable disease who will contaminate the swimming pool water with their infectious sputum, nasal discharges, pus, urine, or other body wastes. A susceptible person may swallow or inhale enough of the contaminated water to become infected with the disease.

(b) Methods.--It is obvious that in order to combat the possibility of such transmission, a rapid and effective disinfectant must be ever-present in the water. There are several possible methods of disinfecting swimming pool water. These methods include the use of ozone, ultraviolet rays, chlorine in the form of free available chlorine residual, and other chlorine compounds called chloramines more recently, and referred to in this chapter as combined available chlorine residual. At present only chlorination can be recommended because chlorine is the only practical, economical, and safe disinfectant which has the quick-acting and residual disinfecting properties. In considering the use of chlorine and chlorine, compounds, the method of destruction of the cell (bacteria) by chlorine, chlorine demand and break-point reaction will be discussed in some detail.

(c) Principles of Chlorination.--The way in which the disinfecting power of chlorine solutions is achieved has been the subject of speculation ever since the time of the first use of chlorine as a disinfectant. Early ideas that the action of chlorine was due to nascent oxygen or to a complete oxidative destruction of the organisms soon had to be abandoned because of the small concentrations of hypochlorous acid (HOCl) required, and because of the failure of other oxidizing agents to work similarly. It was apparent that there was some selective attack on a vital and highly sensitive portion of the cell. According to workers[1] the death of the organism results from a chemical reaction of hyporchlorous acid (HOCl) with an enzyme system in the cell that is essential for the metabolic functioning of the organism. The above theory provides a partial explanation of the extreme sensitivity of organisms to chlorine, since enzymes are present in cells in very minute quantities, and yet are absolutely essential as a catalyst for metabolic activity.

(1) The chlorine demand determines the dosage of chlorine in any given volume of water required to obtain the desired free available chlorine residual level for disinfection. Reactions which lead to a loss of oxidizing chlorine occur. Since hyporchlorous acid (HOCl) is a strong oxidizing agent, its reaction with reducing substances results in the so-called "chlorine demand." The chlorine atom manifests its great tendency to gain electrons and is thereby changed into the chloride ion or organic chloride and loses its oxidizing properties and disinfecting power. Substances such as Iron (Fe), Manganese (Mn), Hydrogen Sulfide (H_2S), and organic mate-

[1] Green, D. E. & Stumpe, P. K. The Mode of Action of Chlorine, Jour. A.W.W.A., 38: 1301 (1946).

rial in the water are responsible for the reduction of the chlorine. After the "chlorine demand" has been satisfied in a body of water the chlorine remaining as an active disinfectant is termed free available chlorine residual. The occurrence of these side reactions is a disadvantage to the use of chlorine as a disinfectant, for sufficient dosage of chlorine must be added to take care of these side reactions before a reliable disinfecting action can be assured.

(2) The use of ammonia in swimming pool treatment as well as other organic amines in the water exert "chlorine demand" in what is termed "breakpoint reaction.[2]" This is a reaction in which, like the combination of compounds like ammonia and chlorine into chloramines, little is known of the fundamental chemistry. However, this phenomenon is of great importance in disinfection of waters used for swimming. Experiments have definitely established several points in the process involving "break-point reaction." Experiments have so far established several points:

The rate of the reaction is strongly dependent on pH. A maximum rate is obtained at about pH 7.5 and decreases rapidly at high and low pH values.

One of the substances concerned in the break-point reaction is probably dichloramine.

The rate of the reaction is only slightly dependent on temperature.

The rate of the reaction is very dependent on the total concentration of dissolved salts.

5. Use Of Ammonia.--Several years of observation has shown that the use of ammonia in swimming pool treatment has a decidedly limited field of application. Extremely large outdoor pools, where chlorine dissipation into the atmosphere is a great problem, can possibly use ammonia to advantage. However, it is thought that in moderately sized outdoor pools and in all indoor pools, better and safer results will be achieved by strict attention to the pH of the pool water and by the use of chlorine alone as a disinfectant.

(a) There are two main objections to the use of ammonia-chlorine treatment in swimming pools. First, it has been found by repeated experiments in many laboratories and will be further substantiated in later paragraphs that the velocity of disinfect-

[2] Fair, Gordon M. et al. The Behavior of Chlorine as a Water Disinfectant. Jour. A.W.W.A. 40:10. (Oct. 1948). pp 1051-1061.

ion--i.e., the speed with which organisms are killed - is much slower with ammonia-chlorine than with chlorine alone. In swimming pools where disease organisms may be transmitted form person to person in a few seconds, it is obvious that a successful disinfectant must be as quick acting as possible. Second, ammonia promotes the growth of algae which become especially troublesome in outdoor pools.

(b) Other objections to the use of ammonia are that it is usually decomposed, especially when present in excess, to form nitrites. Nitrites have an excessive chlorine demand which will tend to inactivate some of the chlorine. Lastly, unless a pool's operator is able to run frequent chemical tests for free ammonia, he will never be able to determine how much ammonia is present in the pool water and as a consequence his control will be in doubt.

(c) Ammonia is usually introduced in the pure gaseous form into the recirculating system. However, it may also be introduced as ammonium sulfate or as ammonium alum. The latter is sometimes used in connection with the coagulation and filtration without the realization that it forms the ammonia-chlorine combination.

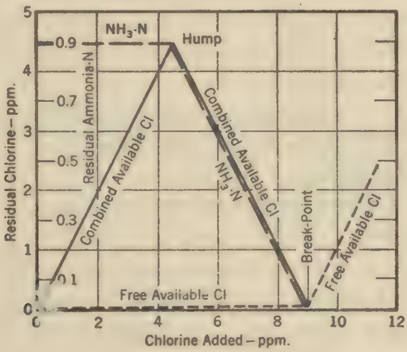

FIGURE 4-1.--IDEAL RESIDUAL CHLORINE CURVE (AMMONIA SOLUTION)

6. The Ideal Residual Curve[3]--For the purpose of illustration figure 4-1 shows an ideal diagrammatic residual chlorine curve in the presence of 0.9 p.p.m. of ammonia-nitrogen. With 0.9 p.p.m. of ammonia-nitrogen initially present, there is no change in the ammonia-nitrogen content until 4.5 p.p.m. of chlorine has been added (the ratio of chlorine to ammonia-nitrogen is approximately 5:1). Until the combined available chlorine residual is at the maximum point (popularly called the "hump") the ortho-tolidine chlorine residual content is the same as the amount of

[3]Butterfield, C. T. Bactericidal Properties of Free and Combined Available Chlorine. Jour. A.W.W.A. 40:12 (Dec 1948) pp 1305-1312

chlorine added, and all of the residual chlorine is present as combined available chlorine.

(a) After the "hump" has been reached, added amounts of chlorine result in corresponding decreases of ortho-tolidine residual chlorine and ammonia-nitrogen, until, when about 9.0 p.p.m. has been added, the chlorine residual content and the ammonia-nitrogen content will be zero (fig. 4-1). Within this part of the curve the residual chlorine present is combined available chlorine. Increments of chlorine beyond this "break-point" (zero point) produce corresponding increases in residual chlorine, and this residual chlorine is free available chlorine.

(b) The ideal curve in figure 4-1 therefore shows that when the amount of added chlorine is exactly enough to achieve the zero point: (1) there is neither free nor combined available residual chlorine present; and (2), the water is entirely free of bactericidal properties. This would be true, in the illustration cited, even though 9.0 p.p.m. of chlorine was added to the water.

(c) Although this exact end-point in the reaction is difficult to attain in practice, it has occurred in several tests which definitely showed that bactericidal action does not take place at this point. That post-breakpoint residual chlorine is free available chlorine may be demonstrated by the test procedure indicated (ortho-tolidine) or by any one of several others which have been developed by chemists.

7. Effects of Temperature and pH of the Water on the Bactericidal Qualities of Residual Free Available Chlorine and Combined Available Chlorine:

(a) At pH 7.0 a residual of 0.6 p.p.m. combined available chlorine produces a 100 percent kill at 22°C., and 1.5 p.p.m. is required to produce the same results at 4°C.

(b) At pH 8.5 residuals of 1.2 and 1.8 p.p.m. combined available chlorine were required to produce a 100 percent kill at 22°C., and 4°C., respectively.

(c) Comparisons cannot be made for combined available chlorine residuals at pH ranges above 8.5 as 2.0 p.p.m. (the maximum used in the tests) did not give a 100 percent kill in 60 minutes.

(d) With free available chlorine residual at pH range of 7.0 and 8.5, the bactericidal properties are not affected by low temperatures as 100 percent kills were obtained in 20 minutes with 0.03 to 0.06 p.p.m. of free available chlorine residual at either 4.0°C., or 22°C.

(e) With free available chlorine residuals at higher pH ranges-- particularly 9.8 to 10.7--the lower temperature markedly affects the bactericidal efficiency.

(f) At pH 9.8, 0.4 p.p.m. residual was required at 4°C., and only 0.06 p.p.m. at 22°C.; at pH 10.7, 1.0 p.p.m. residual was required at 4.°C., and only 0.3 p.p.m. at 22°C.

8. Exposure Time.--Results of studies indicate that if 100 percent kills are to be obtained in the same exposure time, 15 to 60 times (average 30) as much combined chlorine residuals must be maintained as compared with free available chlorine residuals. Thus it can be stated that combined available chlorine residual is a much less efficient bactericidal agent than free available chlorine residual.

9. The Bactericidal Efficiency of Free Available Chlorine Residual and Combined Available Chlorine Residual (sometimes referred to as chloramines or ammonia-chlorine).--The development of chloramine-ammonia and "break-point" processes for the prevention and destruction of both tastes and odors from potable water systems led to recognition of certain facts about disinfection of water with chlorine:

(a) Free available chlorine residual is a much more potent disinfecting agent than combined available chlorine residual.

(b) The standard ortho-tolidine test does not differentiate between free and combined available chlorine residuals.

(c) Both pH and temperature affect the bactericidal efficiency of free and combined available chlorine residuals.

(d) The habit of thinking of residual chlorine without differentiating between free available chlorine and combined available chlorine residuals was responsible for inconsistencies in results obtained and failures to establish satisfactory standard residuals.

(e) Certain tests were performed by the Public Health Service laboratory on bactericidal properties of free and combined available chlorine residuals. The bacteria used for the tests were not limited to the coliform group of organisms, Escherichia coli and Aerobactor aerogenes, but also included strains of Pseudomonas pyocyaneae, Eberthella typhosa and Shigella dysenteriae. The shigella or dysentery group included a number of varieties of shiga, Flexner, Boyd 88, and sonnei strains. Certain minimum standards, with certain supporting data for the proposed safe residuals under various conditions are presented for consideration.

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[4] Butterfield, C. T. Bactericidal Properties of Free and Combined Available Chlorine. Jour. A.W.W.A. 40:12, (Dec 1948) pp 1305-1312

(f) In the application of these proposed standards the safe procedures if there is any doubt about the active bactericidal agent it is safe to assume that all of the residual chlorine present is combined available chlorine residual.

(g) In review of the last few paragraphs it may be said in summary that:

(1) As to time of contact of organisms and bactericidal agent; the longer the time, the more effective the disinfection (time is of essence in swimming pool water disinfection).

(2) As to temperature of the water in which contact is made; the lower the temperature, the less effective the disinfection.

(3) The pH of the water in which the contact is made; the higher the pH the less effective the disinfection.

(4) Thus when the combination of high pH and low temperature is encountered the poorest results are to be anticipated.

10. Minimum Safe Residuals.--In setting up these minimum safe residuals there is a liberal factor of safety to allow for varying conditions, such as:

(a) The frequency with which residual tests are made.

(b) The adequacy of the operators' training and experience.

(c) The reliability of the chlorine feeding method.

(d) The free available chlorine residual.

(e) A safe free available chlorine residual after 10 minutes would be not less than:

0.2 p.p.m. - at pH 6.0 to 8.0.
0.4 p.p.m. - at pH 8.0 to 9.0.
0.8 p.p.m. - at pH 9.0 to 10.0

(f) A safe combined available chlorine residual would be not less than:

1.0 p.p.m. - at pH 6.0 to 7.0.
1.5 p.p.m. - at pH 7.0 to 8.0.
1.8 p.p.m. - at pH 8.0 to 9.0.

(g) Since it is desired to maintain standards of waters used for swimming comparable to potable water, and considering normal temperature and pH ranges of swimming pool waters, free available chlorine residual must be maintained at not less than 0.4 p.p.m. and not more than 0.6 p.p.m. (it must never exceed 0.75 p.p.m.). As combined available chlorine residuals require a higher concentration, a level of not less than 0.5 p.p.m. and not more than 1.0 p.p.m. is the range recommended. Such concentrations cannot be relied upon within pH ranges maintained

in pools to effectively disinfect swimming pool waters since these ranges do not meet the required dosage previously indicated.

11. Tests For Chlorine Residuals.

(a) Ortho-tolidine test for free available chlorine residual. The ortho-tolidine test may be used for determining the amounts of free available chlorine residuals in waters containing interferring substances in quantities as follows: (1) iron--Fe --0.3 p.p.m. (2) manganic--Mn--0.01 p.p.m. and/or (3), nitrite--N--0.3 p.p.m. The characteristic yellow color which develops on the addition of ortho-tolidine test solution to a sample containing free available chlorine residual may be accepted as being due to free chlorine providing the above concentrations are not exceeded. However, if the above concentrations are exceeded the test for combined chlorine (chloramine) residual described below must be used. Standard test kits have been devised for the determination of residual chlorine. These kits utilize the standard ortho-tolidine test solution and permanent disc type color comparator with interchangeable discs for the determination of the pH of water. The ortho-tolidine is oxidized by the chlorine in the water sample and turns yellow to red depending on the extent of the oxidation process. If only a slight amount of chlorine is present in the water the oxidation is slight and thus a pale straw color develops, but in higher concentrations of chlorine the color varies from deep orange, to red or brown.

(b) The ortho-tolidine test. In performing the test three or four drops of the reagent ortho-tolidine is added to the test tube filled to the mark with the sample to be tested (usually 15 ml. of the sample is required). The test tube is then mixed well and read after standing for a period of ten seconds and not less than 5 minutes. To read place the sample in the comparator and turn the comparator color disc to a color that approximates the sample and then read in p.p.m. direct from the comparator.

(c) Ortho-tolidine testing solution.--To prepare the ortho-tolidine test solution proceed as follows:

(1) Weigh out 1 gn. of ortho-tolidine, transfer to a 6 inch mortar and add 5 ml. of "20 percent" hydrochloric acid (previously prepared by adding 100 ml. of concentrated hydrochloric acid, sp. gr. 1.18-1.19 to 400 ml. of distilled water).

(2) Grind to a thin paste and add 150 to 200 ml. of distilled water. The ortho-tolidine goes into solution immediately.

(3) Transfer to a 1000 ml. graduate and make up to 505 ml. with distilled water.

(4) Make up to the 1000 ml. mark by adding the balance (495 ml.) of the 20 percent hydrochloric acid.

The above solution is usually furnished with commercial comparator. Ortho-tolidine test solutions should be stored in amber bottles, should not be kept longer than 6 months, should not be subjected to high temperatures and should not be allowed to stand in direct sunlight. Low temperatures may precipitate the ortho-tolidine as hydrochloride crystals.

(d) Ortho-tolidine - Arsenite test --The test depends on the capacity of a reducing agent, sodium arsenite, to arrest the color reaction resulting from the combination of active Cl with O-T before the more slowly reacting chloramine, and Cl combined with organic compounds, are affected. Interference by Mn, NO_2 or Fe is compensated for by a control portion which is treated with sodium arsenite to neutralize all free Cl and combined Cl followed by O-T, which then reacts only with the interferring agents present.

(e) Technique for performing Ortho-tolidine-Arsenite Tests.

(1) Using 3-oz. or 2-oz. French or square bottles, or 3 cells of a commercial comparator, mark one A. one B and one O-T.

(2) Add 15 ml. of a sample of chlorinated water to each 1-oz bottle or cell; if 2-oz. bottles are used, add 50 ml.

(3) Within 10-15 seconds, add a dropperful of arsenite to A. This reduces organic compounds of Cl. (Chloramines) but not the Fe, Mn, or NO_2. Color is due to free Cl + Fe, Mn and NO_2. Add 1 dropperful of arsenite to B. This reduces Cl and its compounds but not Fe, Mn and NO_2. Then immediately add a dropperful of ortho-tolidine to B. Mix as above. Color is due only to Fe, Mn and NO_2.

(4) Add a dropperful (approximately 0.75 ml.) of ortho-tolidine to O-T and A. Mix by one quick shake.

(5) Hold samples for the required period on contact. (See "READING" below)

(f) Ortho-tolidine Test.

(1) Active residual Cl. Arrange bottles, using A as sample and B as control. Read 3 minutes after addition of the O-T.

(2) False residual. Read portion B alone 4 minutes after addition of ortho-tolidine. If sample is colored or turbid, use an untested sample blank, as in the usual O-T test.

(3) Chloramine. Rearrange bottles, using portions OT as sample and A as control. Read at 5 minutes.

	Read at	Significance
A - B	3 min.	Active Cl.
B	4 min.	False residual
OT-A	5 min.	Chloramine*

(g) Sodium Arsenite Test Solution.--To prepare the sodium arsenite solution dissolve 5 grams of chemically pure sodium arsenite, $NaAsO_2$ chemically pure in distilled water and dilute to 1 liter in a volumetric flask.

I. Arrangement of bottles for determination of free Chlorine

LIGHT. (North sky)

Dist. H_2O	Color Standard (Cl)
SAMPLE (A)	**CONTROL (B)**
1. O-T 2. Arsenite Cl, NO_2 Fe, Mn	1. Arsenite 2. O-T --, NO_2 Fe, Mn

A - B = Color Standard

OBSERVER

II. Arrangement of bottles for determination of chloramines

LIGHT. (North sky)

Dist. H_2O	Color Standard (Cl)
SAMPLE (OT)	**CONTROL (A)**
Chloramine Chlorine Fe, Mn, NO_2	Chlorine NO_2, Fe, Mn

OT - A = Color Standard

If 50 ml. sample is used, the reading for chloramine should be made only after 15 minutes. A temperature of 20° C or over is necessary.

Further information concerning O.T.A. test may be found in the following: The Practical Use of the Ortho-Tolidine-Arsenite Test for Residual Chlorine.

Gilcreas, A.W., and Hallinan, F. J. J. Am. Water Works as., 1944, 36:1343.

Test for Active Residual Chlorine and Chloramine in Water. Hallinan, F. J., J. Am. Water Wks. As., 1944, 36:296.

12. Filtration.--It has been pointed out that the turbidity and organic content of swimming pool water has a decided effect upon disinfection; hence, upon the safety of the pool. Furthermore, turbid or cloudy swimming pools are not attractive to swimmers. Unless the water is changed with sufficient frequency to carry away this foreign material it must be removed by filtration.

Filters may be either the pressure type or the gravity type. Pressure filters are closed tanks containing graded sand and gravel, and equipped with underdrains which draw off the clarified water. Gravity filters are usually rectangular concrete tanks also containing graded filter material and equipped with underdrains. Gravity filters are preferred because they may be designed for the exact needs of the system and are usually more efficient. The majority of pools however, make use of prefabricated pressure filters. Necessary appurtenances in connection with a filter system include a hair strainer, vacuum outlets and hose for cleaning the pool bottom, chemical feeding devices, mechanical chlorinator, water heater, and adequate provision for washing the filters by means of a flow reversal.

(a) Filter Backwash.--Filters must be washed with sufficient frequency so that the loss of head does not become excessive. Pressure filters should always be equipped with loss-of-head gages. In general, filters should be washed before the loss of head exceeds 5 pounds per square inch. Washing should be continued until the wash water becomes clear, which usually occurs in about 5 minutes.

(b) Use of Alum.--The straining action of filter sand alone is not usually sufficient to remove fine suspended material from the water. In order to assist the straining process, a chemical is added to the water which will coagulate the material to be removed and which will form a gelatinous layer on the top of the filter. This layer serves as a very fine "strainer" and is partly responsible for the efficiency of the filter.

Alum is usually fed by means of a simple solution pot connected with the filter so that a small amount of water in passing through the pot, dissolves some of the alum and flows into the filter. The omission of the coagulation and sedimentation steps, as usually practiced in municipal water filtration, renders the

process less efficient, but with proper attention to rate of flow, dosage of alum and filter washing, a fairly satisfactory result may be obtained.

Because of lack of control of alum dosage by the use of a solution pot, it is common practice to add alum only after washing the filter. This still forms the gelatinous layer on the filter which will remain effective until it is broken up and removed by washing. By adding alum only once in each filter run, rather than continuously, the danger of overdosing is avoided. However, if large amounts of dirt or foreign matter are present in the pool it may be necessary to use alum more often. The use of a solution tank and orifice box is recommended if a mechanical dosing device is not obtainable.

Three common forms of alum are available, and all are effective coagulants, but their other properties make them vary greatly in usefulness. Ordinary filter alum (aluminum sulfate) is very soluble in water, so that when fed from a solution pot it is dissolved too quickly. Ammonia alum, (ammonium aluminum sulfate) is slower to dissolve but its ammonia content, in the presence of chlorine, forms ammonia chlorine combinations discussed previously. Even if ammonia chlorine treatment is desired, it is not recommended to use ammonia alum for this purpose because control of the ammonia is practically impossible. The third form, potash alum (potassium aluminum sulphate) is slow to dissolve, is an effective coagulant, does not disturb the other treatment processes and its use is generally recommended.

In a carefully controlled municipal filter plant, the alkalinity of the water is found to be of primary importance in satisfactory coagulation. The alkalinity is, to a lesser extent, also important in swimming pool filter systems; but as control is usually so lacking in accuracy, the effect of alkalinity is not so readily observed. The operator can try varying the alkalinity of the water--keeping the alum dose and other factors constant--and observe the results, thereby arriving at the proper value. Because this depends entirely upon the water being treated, no pre-determined values can be given.

13. Control of pH.

(a) Purpose.--The acid-alkaline balance in water is determined by the pH measurement. The neutral point is indicated by a pH value of 7.0. An acid condition is indicated by pH values lower than 7.0. It is important that the swimming pool water be maintained in a slightly alkaline state. If too much acid is present, delicate mucus surfaces of swimmers will be irritated and the chlorine present in the water will be more noticeable.

Acid is produced by alum treatment of the water prior to filtration and by chemical reactions during chlorination. It is also produced by the decomposition of body-wastes of swimmers.

To remedy this acid condition, the water must be either replaced with fresh water or treated with some harmless alkaline material. On the other hand, chemical changes in some waters will cause the water to become too alkaline and chlorination will become less effective. In this case, it is not practical to add acid material; instead, part of the alkaline water should be replaced with normal fresh water.

(b) pH Test.--To determine the pH of a sample of water, several methods are available. The most practical method for field use is a color-comparison test similar to that described for the determination of residual chlorine. Because pH values of natural waters vary between such wide limits, several different dyes are used--each one being most accurate over a specific range of one or two pH units. The dye most commonly used in swimming pool work is phenol red, which has a range of 6.8 to 8.2. Certain of the chlorine residual test sets mentioned earlier have combination discs, especially made for swimming pool use, with half of the disc giving residual chlorine concentrations and the other half giving pH values on the phenol red scale.

(c) Use of Soda Ash.--Several chemicals can be used in correcting an acid condition in water. In swimming pool practice, the use of soda ash (sodium carbonate) is almost universal. As this material is very soluble in water, the use of a solution pot will not be satisfactory for close control, and if possible, an accurate chemical feeder should be used. It is usually satisfactory however, to apply the required amounts of soda ash directly into the pool, preferably in solution or in the form of fused soda ash bricks. Under ordinary conditions the amount required will be approximately the same as the amount of alum used. Then if the pH becomes too low because of other factors in the pool, more soda ash may be added. Swimming pool water should be maintained at a pH between 7.0 and 8.0.

14. Control of Algae.

(a) Purpose.--Algae may appear in a swimming pool either attached to the walls and bottom or free-floating and dispersed throughout the water. The first type appears as green spots which are usually quite slippery and therefore a hazard. The latter type impart a green turbidity to the water which may at times become so dense as to obscure the bottom of the pool at the deep end. In either case, it is important to prevent algal growth during the initial stage since a tolerance to the treating

chemical may be developed at later stages. Algal growth is most rapid in pools exposed to direct sunlight and is increased through the use of ammonia. The two methods of control are superchlorination and the use of copper sulfate.

(b) Superchlorination.--This treatment is recommended because it possesses all the advantages of complete sterilization and oxidation of all undesirable organic matter without the production of turbidity. Superchlorination should be applied only after all swimmers have left the pool. It consists of building up a chlorine residual of 10-15 ppm.

After this residual has been obtained, the chlorination is shut off but recirculation is continued. Ordinarily by the following day the residual will have dropped to a point that is safe for swimming; however, if necessary the chlorine content may be reduced by adding fresh water or with sodium thiosulfate solution.

(c) Use of Copper Sulfate.--Copper sulfate is not recommended for the control of algal growths in waters having a high pH because a milky precipitate is formed which not only increases turbidity, but also renders the free copper ion non-effective. If the water is of such character that copper sulfate treatment can be used, the amount needed may vary from 0.5 to 5.0 ppm (0.4 to 4 pounds per 100,000 gallons). Early preventive treatment is desirable.

15. Fresh Water Makeup.

(a) Regardless of the extent and effectiveness of the chemical treatment of swimming pools, the addition of at least some fresh water will be required. Soluble salts from the chemicals used, from the body wastes and dirt from the reactions occurring in the pool are constantly being added to the water. These salts are not removable by filtration, and the only remedy is to dilute them by the addition of fresh water or to remove them completely by replacing the entire volume of water. For esthetic reasons too, the addition of fresh water is desirable.

Under average conditions, where the pool water is used in backwashing filters and where there are normal losses from splashing, tracking, evaporation, etc., about 10 percent of the pool water will be replaced daily. Dilution is not considered adequate if the replacement is much less than 10 percent.

16. Bathing Load.

(a) For pools with recirculation and continuous chlorination, the maximum bathing load, that is, the maximum number of swimmers to be allowed in the pool at one time, should be computed on the basis of providing 30 square feet for each swimmer. The total daily bathing load may be computed on the basis of providing for at least 500 gallons of purified water for each swimmer.

17. Responsibility.

(a) The medical officer is responsible for exercising sanitary supervision over swimming pools and bathing areas. Routine inspections should be made to insure that swimming pools are operated in a safe and sanitary manner.

(b) The control of swimmers and pool attendants is the responsibility of an officer so designated by the commanding officer. The officer in charge should make certain that a qualified attendant is on duty at all times. The attendant must have a thorough knowledge of the application and control of chlorine and be able to take the necessary residual chlorine tests required to maintain standards. The attendant should have authority to enforce the rules of safety and sanitation.

18. Cleanliness.

(a) It is almost superfluous to point out the need for strict cleanliness around a public swimming pool. Such an establishment is in reality a combination of public toilet public dressing room and public bathroom. Admittedly, many persons using public facilities are careless and irresponsible, but it is the duty of every operator to provide the best possible facilities and to maintain them in the best possible manner. When public health is so clearly at stake, only the highest standards of sanitation can be considered. It will usually be found that the swimmers will show their appreciation by cooperating.

Toilet rooms, dressing rooms and hallways should be mopped and disinfected at the end of each day, with clean-up inspections during the day. Toilet rooms must be kept clean if the swimmers are expected to use them. Walls and ceilings should be painted a light color and kept clean. Pool walkways should be scrubbed down daily, but not into the pool. Showers must be kept supplied with soap, and paper must always be available in the toilets.

Regardless of the type or capacity of the pool, the water must always be clear and free from floating solids or scum. Floating material can be skimmed off with a hand skimmer or by properly overflowing the pool. Material on the bottom can usually be removed with the vacuum cleaner. If the sides and bottom of the pool become affected with moss or slime, the pool should be drained and scrubbed with a strong chlorine solution. The use of copper sulfate is not recommended in combatting growths in artificial swimming pools.

19. Temperature.-- Excessively warm water causes dissipation of the chlorine and rapid growth of bacteria, and has an enervating effect on the swimmers. The temperature of the pool water should not exceed 70 to 72 degrees F.

20. Personnel Regulations for Swimmers.--Certain common sense rules of conduct have become standard requlations over the entire country. Clear impressive placards listing these rules should be posted at conspicuous places throughout the premises.

"WARNING: Persons with colds, head infections, running nose or ears, catarrh, etc., are warned that swimming and diving tend to force the infection into the sinuses or ears and result in serious if not fatal complications.

(a) All bathers will take a cleansing shower before entering the pool.

(b) Bathers who have been outside the bathhouse or pool enclosure shall not re-enter without passing through a footbath and using a shower.

(c) No person suffering from a fever, cough, cold, inflammed eyes, nasal or ear discharges or any communicable disease will be allowed the use of the pool.

(d) No person with sores or other evidence of skin disease, or who is wearing a bandage of any kind, will be allowed use of pool.

(e) Spitting in, or in any other way contaminating the pool, and spitting on the floors, runways, aisles or dressing rooms is prohibited.

(f) Eating within the pool enclosure is prohibited.

(g) Bringing or throwing into the pool any objects that may in any way carry contamination, endanger safety of bathers, or produce unsightliness, is prohibited.

(h) The presence of dogs, cats or other pets within the pool, pool enclosure or dressing rooms is forbidden."

Section IV.--RECORDS, SAMPLING, AND BACTERIAL QUALITY OF WATERS USED FOR SWIMMING

21. Record of Pool Operation.--Records may seldom be consulted, therefore, some operators decide that such are not important. However, the importance of records lies in the fact that they are available in case of complaints, an investigation, or if needed otherwise to trace down causes of operating difficulties. Complete daily records should be maintained as follows:

(a) Total number of swimmers.

(b) The maximum number of swimmers using the pool at one time.

(c) The length of time pumps and filters are in operation.

(d) The amounts and the time any chemicals are added.

(e) When each filter is backwashed and cleaned.

(f) When the pool is vacuum cleaned.

(g) Residual chlorine readings at least every two hours and at the time of the maximum swimming load.

(h) The pH should be taken and recorded three times daily unless otherwise indicated.

(i) Temperature reading should be taken as often as necessary to maintain the correct temperatures.

22. Submission of Samples for Bacteriological Analyses.-- Samples of swimming pool water should be submitted to the Public Works Department Laboratory or such other laboratory as may be designated by the medical officer for analysis at least once each week during the operating season. Samples must be taken in properly sterilized bottles which will be furnished by the District Public Works Department or medical department. Sampling to ascertain the bacterial condition should be done during periods, or following periods, of heavy patronage.

23. Bacterial Quality of Pool Water.--The recommended standards for purity of swimming pool waters are identical with the requirements of the Public Health Service. (See Public Health Reports, Vol. 61, No. 11 or the latest revision thereof). In general not more than 15% of the samples covering a considerable period of time should contain more than 200 bacteria per ml. or show positive for coliform organisms (confirmed test) in any of five 10 ml. portions of water at times when the pool is in use. Analyses should always be made in accordance with the procedures outlined in the latest edition of Standard Methods of Water and Sewage Analysis of the American Public Health Association. Records of all bacterial analyses should always be maintained by the medical officer.

24. Fill and Draw Pools.

(a) The use of fill and draw pools or intermittent disinfection with hypochlorites is not recommended. Fill and draw pools are difficult to maintain in good sanitary condition at all times. Intermittent disinfection with hypochlorites does not give satisfactory chlorination, especially during fluctuating bathing loads, and hence water of safe bacterial quality cannot be assured.

(b) Wading pools are usually fill and draw type pools and present a major public health hazard if not closely supervised and bacterial standards contained in this chapter strictly adhered to During epidemics of communicable disease such as poliomyelitis these pools should be closed.

25. Natural Bathing Places.

(a) Harmful contamination of natural bathing places may be caused by sewage from ships and boats, sewage from shore establishments, refuse dumping and bathers themselves. The hazards from a relatively small amount of sewage pollution in

proximity to a bathing area is far greater than a large amount at a considerable distance. When swimming from shipboard, the greatest danger, except in polluted harbors where swimming should not be allowed, is from the ship's own sewage. To reduce this danger the discharge of sewage should be prohibited on the side of the ship where swimming is permitted and advantage should be taken of the motion of the water relative to the ship to carry sewage discharges away from the bathers.

(b) Judgment must be used in applying any standard of bacterial purity for natural bathing places, particularly if nearby contamination with sewage is suspected. Natural waters which have a coliform bacteria density of more than 1,000 per 100 ml. are not acceptable for swimming. A coliform bacteria density of less than 50 per 100 ml. indicates a highly satisfactory natural bathing place.

(c) During epidemics or when water borne disease is known to be prevalent usually acceptable beaches or lakes may require extraordinary precautions or restrictions.

26. Sanitary Inspections of Swimming Pools.

(a) Sanitary inspection of swimming pools should include a close check of those features of design, construction, operation and maintenance which directly affect the health and safety of persons using the pool.

(b) The following is offered as a guide in inspecting and reporting of inspections of swimming pools:

(1) Name and location of pool.

(2) Date of inspection.

(3) Size of pool. Capacity in gallons of water.

(4) Filters, number, diameter, recirculating capacity (gpm).

(5) Type of chlorinating apparatus. Maximum capacity of out-put.

(6) Dressing rooms, lockers, showers, toilet facilities-adequate in number, maintained in sanitary condition.

(7) Maximum swimming load during period covered by report.

(8) Chlorine residual reading. pH reading.

(9) Dates of - last backwashing of filters, vacuum cleaning. Is vacuuming cleaning apparatus satisfactory?

(10) Date and amount of additions of - alum, ammonia, copper sulfate.

(11) Is supervision and maintenance adequate? Who is responsible for operation and maintenance? - Name:

(12) Are adequate safety and rescue apparatus available? Is anyone readily available and trained in the use of resuscitation procedures and apparatus? Are adequate rules posted for operation and maintenance of the pool?

(13) Clarity of pool (see paragraph-- this chapter).

(14) Scum cutters adequate. Scum on surface of pool.

(15) Depth of pool - at highest diving point (should be not less than 8' 6") at lowest diving point (should be not less than 6' 6").

(16) Are hand holds, hand rails, safe ladders with rails provided?

(17) Are swimming pool walks provided? Impervious, not slippery, width 4' or more and have a pitch of not less than 3/8" per foot.

(18) Night lighting of pool water and premises.

(19) Flushing system available for flushing down pool area.

(20) Waste disposal sanitary. No source of water pollution.

(21) Slime, moss, algae present pool.

(22) Is residual free available chlorine or combined available chlorine (chloramine) used for disinfection of pool water?

(23) Are adequate pH, free chlorine (ortho-tolidine) and/or combined chlorine (ortho-tolidine-arsenite) testing solutions and apparatuses available and well maintained?

(24) Are dogs or other animals allowed in pool enclosure?

(25) Are swimmers required to take a shower prior to entering the pool or re-shower after playing in the sand?

(26) Is eating allowed in the pool enclosure?

(27) Signature of the inspecting officer.

The above items are not necessarily all inclusive, but are suggested as they may materially affect the health and safety of persons using the pool.

Chapter 5

Water Supply Ashore

Section I.--WATER SUPPLIES

1. The Problem of Pure Water.--A hygienically safe and continuously dependable water supply is one of the necessities of life. Water, like other natural resources, is procured as a raw material, manufactured into a commodity suitable for use and distributed to places of consumption. In North American cities the design of water works and their sanitary control by public health agencies has developed to the point that pure and abundant water supplies are accepted as the natural state of affairs. The provision of abundant supplies has been accomplished at great expense and the safety of these supplies is attained only by raising multiple barriers against the agencies of disease and by maintaining uninterrupted vigilance against the development of sanitary hazards. It is the responsibility of the Navy Medical Department to make sure that barriers to the spread of water-borne disease are adequate. This responsibility implies a field of interest and activity beyond the testing of water samples.

2. Types of Water Supplies Ashore.--Water for naval stations in the United States is often purchased from a nearby municipality. Since this is normally pure water, the water sanitation measures on the station are directed toward discovery and prevention of defects in the distribution system. Where municipal supplies are not at hand or are inadequate, the Navy builds and operates the complete system, which includes collection, purification and distribution works. Protection of the source and control of purification then assume an importance equaling that of preventing recontamination during distribution. The sources that may be utilized are rainwater, ground water, surface water or sea water. Ground water is commonly preferred, but is an unreliable source be-

cause of the great uncertainty as to the quantity and quality of water which will be continuously available. Surface water is more abundant and is more susceptible to quantitative and qualitative study so it is used for most large supplies. Rainwater and sea water find use at advanced bases when surface and ground sources are inadequate. The type of purification required depends on the quality and uses of the water, and may vary from simple chlorination to elaborate treatment to remove minerals as well as bacteria and other micro-organisms. The water purification works in permanent stations are similar to municipal plants. Equipment for advanced bases, on the other hand, is especially designed for lightness, mobility and simplicity of operation.

3. Quantities of Water Required Ashore.

(a) The per capita consumption in shore stations depends on the climate, the standard of living maintained, and on the extent to which water is used for industrial operations. In established bases with adequate bathing and laundry facilities, water consumption for all ordinary uses will average from 75 to 150 gallons per capita daily (gpcd). A figure of 100 gpcd may be remembered as typical. To this amount must be added the quantities required for the operation of water-consuming industries or for supplying the fleet. The needs for fire fighting are cared for from stored reserves. Stored water also compensates for the continual fluctuations in demand, thus making possible the uniform and economical operation of pumps and treatment works. The distribution system is designed to previde for peak quantities, which may exceed the average by several hundred percent, and to supply large quantities of water for fire fighting where the potable supply is used for this purpose.

(b) At well developed advanced bases, water consumption generally reflects a compromise between a desirable abundance and a practical maximum for overseas operations. The maximum amount provided is usually around 50 gallons per capita daily. This quantity is decreased as the supply difficulties increase. At semi-permanent camps no more than 25 gallons per man per day is provided and under actual combat conditions or at newly established bases only a fraction of this amount can be made available. The minimum daily allowance of water in camps and on advanced bases is 5 gallons per man. When the supply is limited to this amount little if any potable water can be used for laundry and bathing.

(c) In the field the uses of water are apt to be restricted to those that are absolutely necessary. One gallon per man

per day may be taken as the absolute minimum; 1-1/2 quarts for drinking between meals, 2-1/2 quarts for cooking and for drinking at meals. Two gallons per man should be considered the desirable minimum under adverse conditions. It has been established that there is no such thing as acclimatization to stringent amounts of water. The water requirements of the human body are as absolute as those of a steam locomotive in that water consumption can be reduced only at the sacrifice of energy output. Furthermore, the desire for water rises sharply during periods of nervous strain. When under fire or in actual combat men consume large quantities of water. If pure water or the means of purification are not available, the danger of drinking contaminated water is greatly increased during such periods. Thus the provision of an abundant supply is a positive measure in the prevention of water-borne disease.

(d) The per capita daily consumption of potable water under various conditions is, therefore, about as follows:

	Gallons
Permanent stations. Abundant supply for all ordinary uses	100
Advanced bases, well established. Adequate supply for domestic type uses	50
Advanced bases, newly established. Minimum supply for all uses	25
Temporary camps and advanced bases during construction. Water for drinking, cooking, and washing. Little, if any, for bathing and laundry	5
Combat conditions. Desirable minimum for drinking and cooking only	2
Combat conditions. Absolute minimum for drinking and cooking	1

Occasionally it may be necessary to provide water for animals and vehicles from the potable supply. The following daily consumption figures may be useful in such cases.

	Gallons
Horse	10
Mule or donkey	6
All draft animals, absolute minimum	3
Car, truck, or other water-cooled engine. Normal	0.1
Car, truck, or other water-cooled engine. Desert	0.5

4. Essential Phases of Water Sanitation.--Water sanitation measures may be divided into the following categories:

(a) Selection of raw water source of good quality and one which is subject to reasonable protection from severe contamination.

(b) Design of supply and distribution works to exclude contamination by eliminating all connections or openings through which non-potable water might be pumped, sucked, diverted, or flooded into the potable water system.

(c) Provision of adequate and well designed and maintained water purification facilities.

(d) Maintenance of proper operating and laboratory control of purification processes.

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(e) Proper disinfection of all new pipe lines and equipment and of all lines that have been opened for repair or alteration.

(f) Routine analytical checks on the potability of water to discover sanitary defects supplemented by prompt and positive corrective action when indicated.

(g) Periodic inspections of sources, facilities, and practices to assure the effectiveness of water sanitation. Failure to carry out any of the above measures properly may permit, sooner or later, the occurrence of that unfortunate combination of circumstances which produce water-borne epidemics.

5. Responsibility for Water Supply.

(a) The commanding officer is responsible for all phases of water supply. In continental shore stations he is assisted by the Public Works officer and the medical officer. The Public Works officer is responsible for the design, construction, operation, maintenance, and administrative supervision of the water works. The medical officer assisted by his sanitation officer has the responsibility of advising when any phase of water sanitation is unsatisfactory and of recommending corrective measures. Under normal conditions adequate protection of water quality can be obtained through cooperation of the medical officer and the Public Works officer. It is wise, however, to confirm recommendations and actions in written communications to the commanding officer. If the situation demands it, a letter to the Bureau of Medicine and Surgery via official channels should produce a solution at the District or Bureau level. The Semiannual Sanitary Report is appropriate for recommendations that are not of immediate urgency.

(b) The medical officer's responsibility for water supply in the field and on advanced bases varies greatly with the situation. During the initial phase of amphibious operations each unit may carry in its own water or may depend on local supplies disinfected in lyster bags and canteens. The responsibility for the adequacy and purity of the water under these conditions falls largely on the unit medical officers. They must take part in initial plans for operations and arrangements for supplies and must indoctrinate all hands in the fundamentals of water sanitation. The unit commander will depend heavily upon his medical officer to locate sources of water and supervise its treatment and distribution. When filtration or distillation equipment has been brought in by the Marine Engineers or by the Construction Battalions, the responsibility for water treatment shifts to these organizations, thus reducing the need for such close supervision by the medical officers or their representatives. Later on when the advanced base has been

well established, the normal division of responsibility between the Public Works or engineer officer and the medical officer develops.

(c) Satisfactory water sanitation in the field rests almost entirely on thorough planning and preparation. All unanticipated problems must be solved on the spot. A report of difficulties or failures may, however, lead to improvements in preparations for later operations.

Section II.--NATURAL WATER SOURCES

6. Types of Water Sources.--The types of natural water are: (a) Rainwater, (b) surface water, (c) ground water, and (d) sea water.

7. Rainwater.

(a) Rainwater resembles distilled water in quality. Its freedom from minerals (softness) makes it an excellent water for cooking, bathing, and for laundries and boilers. However, it lacks palatability and is aggressive or corrosive because of the absence of minerals. Rainwater contains dissolved gases as well as dust particles and bacteria swept from the air. As a source, rainwater is important only on small islands or in isolated places where ground water is salty and surface water inadequate. Under these conditions, where the requirements are small and precipitation heavy, rain may furnish an adequate supply for all uses. In many places it will prove valuable in augmenting the supplies from other sources.

(b) Rainwater is collected from the usual type impervious surfaces such as roofs, concrete pavements, and barren rocks or from areas rendered impervious by spreading tarpaulins or galvanized sheet metal. The volume derived depends on the catchment area and on the amount of rainfall. The volume in gallons that may be recovered from an impervious surface equals the horizontal area in square feet multiplied by one half the rainfall in inches. In order to make this amount of water available, storage must be provided to hold water for use during the periods between rains. If precipitation is uniformly distributed throughout the year, storage equal to the average monthly rainfall should be sufficient. If there is an annual wet season, with little or no rain during the intervening months, the gallons storage needed to fully utilize rainwater will equal the horizontal catchment area in square feet multiplied by one half the annual rainfall in inches, multiplied by one twelfth the length of the dry season in months. Rainwater may be stored either above or below ground in any convenient tank or container. Evaporation will be reduced and the water

kept cooler, and thus more palatable if stored in underground cisterns. Storage receptacles should be protected from dust and dirt, and from contamination by polluted surface or ground water. They should be covered or screened to prevent mosquito breeding or the entrance of vermin.

(c) The surfaces from which rain is collected are usually subject to contamination by birds, animals, and dust, and if at ground level perhaps by human wastes. The first rain which falls during a storm flushes these substances from the surface, so should be wasted. Rainwater should be chlorinated unless it can be demonstrated that there is no chance of contamination during collection and storage.

8. Ground Water.

(a) Water in the interstices of saturated earth and rock is known as ground water. The water table is the upper level of the zone of saturation or the level at which water stands in wells. The ground water body is fed by infiltration of rain and melting snow and is depleted by flow from springs, withdrawals from wells and by seepage into swamps and streams. No more water can be continuously taken from the ground than enters by infiltration from the surface. The rate of lateral movement through the ground and thus the rate of withdrawal from the wells is governed by the porosity of the earth. Large yields of ground water are obtained from properly constructed wells penetrating beds of gravel and coarse sand or creviced and cavernous rock. Wells in clay or dense unfractured rock yield little water. Artesian waters rise from porous strata overlaid by confining beds of impervious clay or rock.

(b) Fresh ground water on volcanic or coral islands usually occurs as a lense floating on the salt water. The flushing action of fresh accretions of rainwater from the surface and the elevation of the water table above sea level holds back the salty water. The recovery of this water is best accomplished by means of wells dug on high ground near the center of the island. If possible, the water should be removed at low tide by a skimming process which will prevent lowering the water table sufficiently to pull salt water up from below. Brackish water will appear in these wells if the level is drawn down to or below sea level for any considerable period of time. A broad shallow well in coral, a tunnel or gallery into volcanic rock, not extending below sea level, will prevent excessive drawing on the well.

(c) The quality of ground water is determined by the environment through which the water passes. The normal percolation processes filter out suspended matter and bacteria.

Bacterial activity in the soil removes organic matter and replaces the oxygen with carbon dioxide generated by decomposition. The carbon dioxide renders the water aggressive and in the presence of limestone, coral or other soluble rock the mineral content of ground water may rise to high levels. In areas where cavernous limestone or volcanic rock are near the surface, water may enter through sinkholes, fissures, and other openings. This water retains the objectionable characteristics of surface water, such as high turbidity and bacteria content, and its character is little improved by movement through open passages in the rock. The presence of free flowing channels in the ground or a rise in turbidity of ground water following rains are danger signals.

(d) All wells are sooner or later subject to pollution either through flow in open formations in the ground, by leakage from the surface down outside the casing, or through perforations in the casing as corrosion progresses. Well water therefore should be adequately chlorinated.

9. Surface Water.

(a) Surface water supplies are obtained from rivers, streams, lakes, ponds, and pools. Since the amount and quality of water available from a surface source will vary widely as the season changes, it may be necessary to investigate the history and habits of a stream or lake before placing too much dependence on it. Elaborate hydrological studies should precede the choice of the source for a large supply. In the field there is neither time nor need for such studies.

(b) Surface sources are supplied by run-off following storms and by the flow or seepage of water from the ground. During rainy weather streams are turbid and polluted with material washed from the ground surface. Because of the rapid movement and interference with natural purifying processes during floods, sewage and other contamination may be carried for long distances. Dry weather flow consists primarily of ground water, so streams are clear and more highly mineralized during dry periods. Self purification processes are most active in a clear stream and though the dilution of sewage and other wastes is reduced during dry weather, the recovery of stream purity may take place in a relatively shorter stretch of channel. A normally sluggish stream is high in organic matter and may be odorous because of dense algae growths and the formation of sludge banks. Such streams are poor sources for a water supply. Mountain streams and lakes remote from inhabited areas are usually clear and contain water of excellent quality.

(c) Surface water must always be disinfected and should receive such additional treatment as the situation permits to render it free of turbidity, tastes, and odors. In areas where amebiasis is prevalent, all water should be filtered or, where this is impossible, should either be boiled or disinfected by super-chlorination, or by other chemical processes known to destroy amebic cysts. Surface waters subject to contamination by chemical warfare agents must be examined for the presence of these substances and avoided or purified as the situation demands.

10. Sea Water.--The sea serves as the major source of water for the fleet. Ashore it is utilized only in the absence of adequate fresh water sources. Sea water contains up to 37,000 parts per million of dissolved salts which must be removed by distillation. Since shallow coastal water may carry considerable organic material and turbidity or be polluted with oil or other wastes, it is usually desirable to filter sea water before pumping it to stills located on the beaches. Advantage may be taken of natural filtration and the diluting effect of ground water by distilling water withdrawn from shallow wells located along the shore. Since distillation is an expensive process, all available fresh water sources should be fully utilized as soon as the military situation permits.

11. Selection of Source.

(a) The choice of a water source is influenced by quantity, quality, ease of procurement, ease of purification, and by other factors. Supplies for permanent shore stations are usually selected on the basis of detailed engineering studies of all reasonably promising sources. However, during military operations, a hasty estimate of quality and adequacy of a source may be all that is possible. A water reconnaissance is usually made to find and look over available sources and to select that which appears most suitable.

(b) The considerations of quality which merit study are:

(1) Freedom from contamination by sewage or other wastes and from enemy pollution with chemical agents or bacteria.

(2) Freedom from turbidity, color, and taste.

(3) Freedom from excessive amounts of organic and mineral substances.

(c) There is a tendency, based probably on recreational experience, to locate military camps along stream banks or close to shore even though the health hazards may be much

greater in these areas than on high and dry ground not far distant. In planning camps and bases in the tropics too much importance ought not be given to the convenience of locating near a source of water. The effort required to pipe or haul water to healthier sites may be insignificant when compared with the difficulty and expense of controlling insects in the swampy areas along a water course.

Section III.--WATER FROM MUNICIPAL SOURCES

12. Quality of Municipal Water.--Hygienically pure and esthetically pleasing water is supplied in practically all American communities having public water supply systems. Water consumers have grown to expect a palatable as well as a safe water and are ready with complaints whenever water has a slightly unpleasant taste. With few exceptions, municipal supplies in the United States are palatable and meet the quality standards of the United States Public Health Service. This situation does not prevail widely outside the United States. All water supplied from public systems abroad should be considered of doubtful quality and should be tested and, if necessary, disinfected.

13. Responsibility of the City.

(a) When municipal water is purchased for a naval station, the city is under legal obligation to deliver water that is pure and safe from possible contamination. The city is not obliged, however, to deliver water containing residual disinfecting agent. If free chlorine is used to disinfect water at the purification plant, maintenance of residuals at distant points in the system may be impossible without so charging the water with chlorine that it would be unfit for use in areas near the point of chlorination. When the ammonia-chlorine process is used, residual action may be maintained more easily, but disinfection is less certain because of the relative ineffectiveness of chloramines.

(b) The city is responsible for protecting the purity of water throughout its distribution system. It is well recognized that cross-connections with polluted supplies constitute a danger to the health of the community. Police power regulations are, therefore, in force almost everywhere forbidding or controlling such cross-connections and giving representatives of the municipality the right to inspect points of possible cross-connections on the consumer's property and the right to discontinue the public supply when improper cross-connections are found.

(c) In order to assure the safety of the water, the city or other water supply agency must sample and test the water with reasonable frequency at points distributed throughout the system, and on request must supply the results of these analyses to consumers. The city's water works system and its operating practices are normally open to inspection and review.

14. Responsibilities of the Navy.--The Navy is responsible for the protection of the purity of water during distribution on its premises. It is further obligated to permit periodic inspections by representatives of the water supply agency charged with protecting the public supply. The Navy is entitled to demand delivery to its premises of a pure, wholesome, and safe water and should carry out laboratory tests of water at the point of delivery when there is question as to the quality of water purchased.

Section IV.--ANALYSES AND STANDARDS

15. Water Analyses and Standards.

(a) The term "safety" as applied to potable water indicates the degree of reliability of the measures used to assure a supply uniformly high in quality. The safety of a supply depends on the protection of the source; the purification processes used and the excellence of their design and operation; the proper design, construction, maintenance, and operation of pumping stations, reservoirs, and distribution systems; and on the absence of cross-connection or other means whereby nonpotable water may enter the system. The safety of a water supply is judged by (1) periodic sanitary surveys of all physical features of a water system and an investigation of operating and maintenance practices; and (2), routine laboratory analyses of water quality.

(b) Two types of quality standards are used in water sanitation practice: (1) standards for certifying public supplies on the basis of numerous past laboratory analyses and (2), standards for judging the current safety of a supply from the individual test results.

(c) The bacteriological examinations recognized as being of most value are:

(1) The count of total colonies developing on agar or gelatin in 48 hours at 20° C.

(2) The count of total colonies developing on agar in 24 hours at 37° C.

(3) The quantitative estimation of organisms of the coliform group.

Of these, the test for the coliform group is the most significant because it affords the most nearly specific test for the presence of fecal contamination. Only this test is included in the bacteriological standards recommended by the United States Public Health Service. Plate counts, when regularly made, are useful in controlling water purification processes and in determining the current safety of a water supply.

(d) The standards adopted by the Public Health Service, 6 February 1946, for drinking and culinary water supplied by common carriers in interstate commerce are used throughout the United States for certification of water supplies and for judging the past performance of sanitation measures. The numerical values specified in the Public Health Service Standards are such that communities with reasonably safe supplies can qualify to furnish water for common carriers. In preparing these standards it was reasoned that persons from such communities are entitled to be served, while on interstate travel, water equal in quality to that which they receive at home. A lack of understanding of the background and purpose of the Public Health Service Standards has lead to some criticism, particularly when an attempt is made to use these standards for judging the significance of individual test results.

(e) The Public Health Service Standards are reproduced here with such modification on the side of conservatism as appears warranted for Navy use. Standards appearing herein should be looked upon as a guide to naval sanitation practice, but shall not be considered as official Navy standards. Water is procured and used under such wide variety of circumstances in the naval service that no single set of standards can be designed to fit all situations. The policy of the Navy is to forbid consumption of any water that might detrimentally effect the health and efficiency of personnel. Since the presence of pathogenic organisms can normally be demonstrated only by consumption of the water, a variety of analytical and survey technics that provide circumstantial evidence must be used for judging the safeness of a water.

16. Standard as to Source and Protection.--The water supply shall be obtained from a source free of pollution or shall be adequately protected by artificial treatment. The water supply system in all its parts shall be free from sanitary defects and health hazards and shall be maintained at all times in a proper sanitary condition.

17. Bacteriological Standards.

(a) The Public Health Service standards for certification of supplies are based on standard samples each consisting of

five standard portions. Standard portions may be either 10 milliliters or 100 milliliters. The bacteriological quality shall be in accordance with (1) and (2) when 10 milliliter portions are used and in accordance with (3) and (4) when 100 milliliters are used.

(1) Of all the standard 10 milliliter portions examined per month in accordance with the specified procedure, not more than 10 percent shall show the presence of the coliform group.

(2) Occasionally 3 or more of the 5 equal 10 milliliter portions constituting a single standard sample may show the presence of organisms of the coliform group, provided that this shall not be allowable if it occurs in consecutive samples or in more than: (a) Five percent of the standard samples when 20 samples have been examined per month. (b) One standard sample when less than 20 samples have been examined per month.

Provided further that when three or more of the five 10 milliliter portions constituting a single standard sample show the presence of organisms of the coliform group, daily samples from the sampling point shall be examined until the results obtained from at least two consecutive samples show the water to be of satisfactory quality.

(3) Of all the standard 100 ml. portions examined per month in accordance with specified procedure, not more than 60 percent shall show the presence of organisms of the coliform group.

(4) Occasionally all of the 5 equal 100 milliliter portions constituting a single standard sample may show the presence of organisms of the coliform group, provided that this shall not be allowable if it occurs in consecutive samples or in more than: (a) Twenty percent of the standard samples when five or more samples have been examined per month. (b) One standard sample when less than five samples have been examined per month.

Provided further that when all five of the standard 100 milliliter portions constituting a single standard sample show the presence of organisms of the coliform group, daily samples from the same point shall be examined until the results obtained from at least two consecutive samples show the water to be of satisfactory quality.

(b) These standards may be interpreted as simply implying that the mean density of organisms of the coliform group shall not exceed about 1 per 100 ml. The rather complex wording of the standards results from the need for taking into account two facts:

(1) that according to the laws of chance a density of 1 per 100 milliliter may be exceeded in a small proportion of the samples tested even though the mean density is actually 1 per 100 milliliter and;

(2) that variations exceeding certain amounts with various frequencies indicate potential danger even though the average quality of the water over a period of time may be satisfactory.

(c) There are not widely accepted standards for judging the current safety of a water supply from individual test results. Unfortunately the difficulty in judging the significance of a single bad sample and in deciding what should be done about it is so great that no uniform rules can be developed. Nevertheless, one of the most important reasons for testing water is for determining from day to day whether sanitation measures are functioning properly. Efficient filtration and chlorination should yield a water free from "presumptive coli." If a single positive tube occasionally appears in the five comprising a standard sample no action would be indicated other than a check to see that chlorine residuals had had been continuously adequate. However, if several tubes were positive or if single positives appeared frequently, chlorination should be stepped up; or if chlorination had been satisfactory, a search should be made for the source of trouble. A majority of positive tubes in consecutive samples would normally indicate a sufficiently serious breakdown in water sanitation to justify a careful investigation of the condition of the system, the water meanwhile being regarded as unsuitable for use unless boiled.

(d) Well operated purification plants produce water with a 24-hour 37° C. plate count averaging between 2 and 10 colonies per milliliter and rarely exceeding 50 per milliliter. Plate counts exceeding a reasonable maximum require explanation. A limit of 200 colonies per milliliter is often used. Plate counts running into thousands of colonies per milliliter in water that has been chlorinated almost always indicate sanitary defects even though tests for the coliform group are negative.

(e) Experience suggests that no serious hardship is imposed by regarding a positive presumptive coliform test, without further differentiation, as a index of fecal contamination. Laboratory technics are simplified and a higher standard of safety attained where this practice is followed. In any event the appearance of gas in the presumptive test is a sign of undesirable possibilities.

18. Physical Standards.--Water should have a turbidity less than 10 ppm (silica scale), a color less than 20 (standard cobalt scale), and should be free of objectionable tastes and odors.

19. Chemical Standards.

(a) The chemical quality will ordinarily be satisfactory if the water satisfies the bacteriological and physical standards and the chemical standards, that lead (Pb) not exceed 0.1 ppm and fluoride not exceed 1.5 ppm. Salts of cadmium, arsenic, selenium, barium, hexavalent chromium, heavy metal glucosides or other substances with deleterious physiological effects should not be allowed in the water supply system. Ordinarily periodic analysis for these substances need be made only if there is some presumption of unfitness because of them. The following chemical substances should not occur in excess of the following concentrations:

Lead (Pb)	0.1 ppm.
Fluoride (F)	1.5 ppm.
Copper (cu)	3.0 ppm.
Iron (Fe) and Manganese (Mn)	0.3 ppm.
Magnesium (Mg)	125 ppm.
Zinc (Zn)	15 ppm.
Chloride (Cl)	250 ppm.
Sulphate (SO_4)	250 ppm.
Phenolic compounds	0.001 ppm.
Total solids	1,000 ppm.
Total solids preferable limit	500 ppm.

(b) Since the significance of these limits is different for the various chemicals, judgment must be used in their application. For example, the permissible limit of lead should not be continuously exceeded in any supply used for considerable periods of time by the same individuals. On the other hand, iron and manganese contents greatly in excess of the stated limit will result only in undesirable laundry, vegetable, and plumbing fixture stains. Permissible limits of chemicals in water to be used for high pressure boiler feed will be much lower than those stated above.

20. Methods of Analysis.--The analyses used to determine the bacteriological, physical and chemical characteristics of

water shall be made in accordance with the Standard Methods for the Examination of Water and Sewage, American Public Health Association, or (in cases not covered) in accordance with the Official and Tentative Methods of Analysis, Association of Official Agricultural Chemists.

21. Sampling for Bacteriological Analyses.

(a) The frequency of sampling and the location of sampling points on the distribution system should be governed by the local situation. When difficulty with water sanitation is experienced or is anticipated, the frequency of sampling should be increased. The desirable minimum water samples for bacteriological test on continental shore stations is one per week for all stations having a complement of less than 5,000 men and about one per week for each 5,000 men in larger activities. Samples should be collected at the place where purified water enters the system and at points on the distribution system selected to produce the maximum information concerning the cause of any abnormalities in water quality.

(b) Samples must be collected aseptically and if the water contains residual chlorine, in sodium thiosulfate treated bottles. bottles.

(c) It is difficult to obtain samples from an ordinary spigot without the water being contaminated by leakage around the turnoff stem or by bacteria on the lip of the faucet. The most satisfactory method of sterilizing the spigot is by the liberal use of a blow torch. In filter plants and laboratories, special sampling outlets are sometimes provided from which a small stream is allowed to run continuously. In collecting samples from open tanks or reservoirs, a swinging motion of the arm should be used to prevent any water which may have touched the hands from entering the bottle. Samples should be promptly transported to the laboratory and, if possible, planted immediately upon arrival. If water samples must be shipped or stored, they should be properly refrigerated.

22. Laboratories.--Epidemiological Control Units are equipped with full laboratory facilities for the bacteriological analysis of water. Their services are available to all activities within the major commands to which they are assigned. Some of the laboratories maintained by the Bureau of Yards and Docks for the control of filter plant operation are equipped for bacteriological analyses. In the absence of conveniently located naval water laboratories, advantage should be taken of the bacteriological facilities in naval hospitals or the services of state laboratories enlisted.

Section V.--CHEMICAL WARFARE AGENTS

23. Responsibilities.--In the few instances where contamination of water supplies with chemical agents has been encountered, casualties have been high. It is, therefore, important to test water for chemical warfare agents whenever there is any reason to suspect their presence. The Medical Officer is responsible for making these tests and if an uncontaminated source cannot be found, the group responsible for procurement must decontaminate the water.

24. Toxic Limits.--The toxic limit for lewisite is 10 ppm as As_2O, provided the water is chlorinated by the standard procedure for bacterial purification and is used for not more than one week. Nitrogen mustards in concentrations of 10 ppm have produced vomiting in men but have not caused actual casualties. In higher concentrations they are extremely toxic. Mustard dissolves slowly in water but may be found floating in tiny globules, as a film on the surface or collected in pools on the bottom. The limit for cyanogen chloride and cyanide is 10 ppm.

25. Reactions with Water.--The three vesicants - lewisite, mustard, and nitrogen mustards - all react with water to form hydrochloric acid and the hydrolysis product corresponding to the agent. Lewisite reacts with water practically instantaneously forming the hydrolysis product "lewisite oxide," which is toxic and somewhat vesicant. Mustard reacts with water to form the nontoxic thiodiglycol. A solution containing 100 ppm mustard becomes non-toxic at the end of one hour. Some types of mustard contain a highly odorous compound which renders the water non-palatable even after hydrolysis. Nitrogen mustards hydrolyze slowly to a nontoxic product. A solution containing 100 ppm may remain toxic for four to six days. Cyanogen chloride, cyanide, and heavy metal salts dissolve in water but do not react extensively with it.

26. Water Testing Kit.--For the sake of simplicity, analytical procedures have been developed to employ dry reagents which are furnished as tablets or pellets of proper size. Except for warming with the hand in some of the tests, no heat is required. The reagents and equipment are packed in a pocket-sized transparent plastic container, approximately 5-1/2" x 3-3/4" x 1-3/4", which is divided into 10 compartments and contains equipment for testing 15 samples of water.

27. Application of Water Testing Kit.

(a) The primary purpose of the kit is to detect contamination by chemical warfare agents in the raw water. The

limits of the sensitivity of the tests are on the safe side.

(b) If none of the tests indicates amounts of chemical agents in the raw water beyond the specified toxic limits, the water can be used after usual treatment at water points or in Lyster bags without any specific decontamination procedure for chemical agents.

(c) Under most conditions a positive result for any of the tests included in this kit will indicate probable contamination in which event the water should not be used until a complete analysis can be made. More complete testing equipment is required for the quantitative determination of contaminants. Such quantitative tests are under the cognizance of the group responsible for the procurement and treatment of water.

28. Sensitivity and Limitations of the Tests.

(a) If the tests are carefully performed, the threat of serious casualties from contamination of the water with known agents will be avoided.

(b) The arsenic test will show whether any arsenic is present or not.

The lengths of stain produced by 5, 10, and 15 ppm of arsenic in the form of organic arsenicals are sufficiently different so that one can tell approximately how much arsenic is present. Inorganic arsenite or arsenate produces very long, dark stains at the above concentrations.

(c) The p^H test is a general screening test. Any water with a p^H below 6.5 or above 8.5 should be suspected of contamination.

(d) The test for mustards will detect mustard of the nitrogen mustards in 5 ppm. Thiodiglycol will not react. Ethyl iodoacetate and chloroacetophenone will also react, but these can be detected readily by their odor so it is thought they will cause no difficulty. Cyanogen chloride yields a yellow color with the RA tablets alone and can be detected as low as 10 ppm. No blue color develops when the RB tablet is added.

(e) The ortho-tolidine reaction used to detect chlorine residuals in the chlorine demand test is sensitive to 0.1 ppm of chlorine. A chlorine residual does not mean a safe water. It has been shown that water contaminated with mustard or thiodiglycol may show a chlorine residual and actually still have a chlorine demand. An excess of 4 to 5 ppm of chlorine above what is needed for the actual chlorine demand is necessary in order to have complete reaction between the chlorinating agent and the mustard or thiodiglycol. If this condition is not met, the water will show a chlorine residual as determined by

the ortho-tolidine reaction when it still has a chlorine demand. Other colors may be obtained when using the ortho-tolidine reaction. If the color is blue or green, it means there is too much ortho-tolidine for the amount of chlorine present. A red or orange color means that too great an amount of chlorine has been added.

29. Interpretations, Limitations of Tests.

(a) Negative results from all of the tests indicate that the water is safe for use after chlorination insofar as chemical warfare agents are concerned. A positive result for any one of the tests is presumptive evidence that the water is contaminated with a chemical warfare agent. Water showing a positive result for any one of the tests shall not be used without special treatment to remove the chemical warfare agent except in cases where it can be clearly demonstrated that one or more of the limitations specified below is applicable.

(b) The test for arsenic allows some latitude in the interpretation of the results. If the stain on the test is not longer than 1/4-inch, the arsenic content is not more than 10 ppm as organic arsenic. Water with this concentration of organic arsenic may be used for a period not to exceed 1 week because of possible cumulative effects, provided all the other tests are negative and the water is thoroughly chlorinated. If the stain is longer than 1/4-inch the water shall not be used.

(c) A pH below 6.5 should be regarded with suspicion unless the character of the water source seems to indicate a naturally low pH. Contamination of the water by mustard, the nitrogen mustards, or arsenicals would lower the pH as all these chemical agents release hydrochloric acid in water solution. A pH above 8.5 probably means contamination with some basic material as potassium cyanide.

(d) If the test for mustard and the nitrogen mustards is positive, the water should be rejected for all purposes. Water may pass the test for nitrogen mustards and still give symptoms if consumed in large quantities. Hence, the water should not be used without special purification if even the faintest blue color develops. When the result of the test is questionable, the amount of water permitted per man, at the first drinking, should be limited to 1/2 pint; if no symptoms of nausea or vomiting develop during the succeeding 2 hours, the water may be used freely thereafter.

(e) A high chlorine demand means contamination with mustard, thiodiglycol, arsenicals, or pollution by organic waste material. If the arsenic test is negative, the chlorine demand is a measure of contamination by mustard. However,

the water may also be contaminated with the nitrogen mustards which do not react in the chlorine demand test.

30. Use of the Kit.

(a) The field kit for water testing is designed as a reconnaissance kit. Its purpose is to screen out sources of water so contaminated with chemical agents that they cannot be rendered potable by customary field treatment methods, such as chlorination in the Lyster bag. Individuals performing the tests must have normal color vision.

(b) Negative tests indicate water suitable for use by troops after chlorination.

(c) Subject to limitations listed in paragraph 29, if any of the tests are positive, the water should not be used until a more complete analysis can be made.

(d) The main purpose of the kit is to detect contamination by chemical agents in raw water. It is not designed for use in testing treated water. Chemical reactions during water treatment invalidate the interpretations.

31. Action When Water is Contaminated (Poisoned) with Chemical Agents.

(a) If contamination by chemical warfare agents is discovered in otherwise suitable water, it should be reported promptly to the commanding officer so that the matter can be brought to the attention of everyone concerned.

(b) The commanding officer will establish the necessary safeguards to prevent men from drinking the poisoned water.

(c) An alternative source of water should be sought.

(d) If a source of uncontaminated water cannot be found, consideration should be given to moving to a different location, or to importing purified water.

(e) In any event, the contaminated water should not be used by men until it is treated to remove or render harmless the chemical warfare agent.

32. Purification of Water Contaminated (Poisoned) with Chemical Agents.

(a) The purification of poisoned water is very difficult and should be resorted to only in extreme emergency. Every effort should be made to find an uncontaminated supply. Aboard ships having evaporators, poisoned water should be disposed of and the system thoroughly flushed with water distilled from an uncontaminated source. Distillation or evaporation cannot be relied upon to remove chemical warfare agents. Only trained personnel should attempt the treatment of poisoned water. They should work under the direction of the chemical defense officer and the officer charged with the procurement and treatment of

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water supplies. The treated water must be made palatable and free of bacteria.

(b) Water to be treated to remove chemical warfare agents must be drawn from the intermediate levels of the source with a minimum disturbance of the surface and no disturbance of the bottom.

33. Treatment of Large Volumes.--The following procedure should be used in treating large volumes of water contaminated with chemical warfare agents.*

(a) The contaminated water is pumped into a suitable reservoir and a quantitative analysis made by the responsible officer.

(b) It is then treated with activated carbon (200 mesh) in the following doses:

(1) For lewisite, 30 ppm (30 mg./1) carbon for each ppm. (mg./1) lewisite.

(2) For mustard, 30 ppm. (30 mg./1) carbon for each ppm. (mg./1) mustard.

(3) For nitrogen mustards, 60 ppm. (60 mg./1) carbon for each ppm. (mg./1) nitrogen mustards.

(c) The carbon and water are mixed for 20 minutes to insure complete adsorption of the agent by the carbon.

(d) 175 ppm. (175 mg./1) of coagulant is added to the carbon-dosed water, together with sufficient alkali to give optimum coagulation.

(e) After thorough, gentle mixing, the water is allowed to coagulate and clarify by sedimentation for 30 minutes.

(f) The supernatant water is filtered through the portable water purification unit, at normal rate of 8 to 10 gpm, or preferably more slowly.

(g) The filtered water must be tested quantitatively to see that it meets the following requirements:

(1) Mustards -- not more than 2 ppm. (2 mg./1).

(2) Lewisite (arsenicals)--not more than 20 ppm. (20 mg./1).

(3) p^H above 5.

(4) Chlorine demand -- less than 5.

(5) No chemical odor or taste.

34. Treatment in Lyster Bags.--The procedure for treatment in lyster bags to remove chemical agents should be as follows:*

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*Defensive Chemical Warfare Manual, FTP 222, United States Fleet, Headquarters of the Commander in Chief (1944).

(a) When the portable water purification unit is not available, small volumes of water can be decontaminated by using two Lyster bags or other containers of similar capacity.

(b) If testing equipment is available to identify the contaminating agents and determine their concentrations, add activated carbon in the dosages given in paragraph 5-11, (2), above, to the water in one Lyster bag. If the identities and concentrations of contaminants are unknown, add 2 pounds activitated carbon.

(c) Stir for 20 minutes.

(d) Add 1 ounce of alum and sufficient alkali to give optimum coagulation. These chemicals should be dissolved separately in small volumes of water prior to their addition to the Lyster bag.

(e) After thorough, gentle mixing, allow to coagulate and clarify by sedimentation for 30 minutes.

(f) Siphon the supernatant water to another Lyster bag (preferably through a filter).

(g) After testing to insure that the requirements of paragraph 33, (g), above, are met, the water in the second Lyster bag must be chlorinated.

35. Chlorination of Chemically Contaminated (Poisoned) Water.--Chlorine reacts with some of the chemical agents making it difficult to remove them by activated carbon and alum treatment. Therefore, chlorination should be carried out only after filtration through the portable purification unit, and the chlorine feed-line must be connected to the effluent pipe from the filter. In the case of treatment in Lyster bags, chlorine is added in the second Lyster bag.

Section VI.--DECONTAMINATION (DISINFECTION) OF MAINS AND EQUIPMENT

36. Definitions.--Decontamination (disinfection) is here used to designate the treatment of mains and equipment by thorough flushing followed by filling with highly chlorinated water for the purpose of making them clean and destroying harmful micro-organisms growing on or adhering to internal surfaces. The term is adopted because of its use by forces afloat to describe this treatment. Avoid confusing this use of the term "decontamination" with its use to indicate treatments carried out to render harmless the agents of chemical warfare. Disinfection (chlorination) indicates the treatment given water to make it potable by destroying micro-organisms in the water. After a water system has been "decontaminated," it may be used to distribute "disinfected" water.

37. Importance of Decontamination.--All parts of a water collection, purification, and distribution system are subject to gross contamination during the period of construction. Pipe, valves, and other equipment and materials scattered on the ground or in roadside ditches near the job accumulate surface washings and are often inhabited by small animals. It is common practice for construction personnel to urinate in the trenches or other excavations where equipment is being installed. It is, therefore, necessary to thoroughly flush all newly installed works and to sterilize them with heavily chlorinated water. All underground distribution systems leak to some extent. When the usual internal pressure is maintained, this leakage is outward; but when pipes are dewatered for alterations, repair, or extension, the possibility of the inward leakage of shallow polluted ground water constitutes a sanitary hazard. Distribution lines that have been dewatered and other parts of the system that have been opened must, therefore, be disinfected before being placed in operation.

38. Decontamination Procedures.

(a) Decontamination methods should incorporate the following steps:

(1) Thorough flushing with potable water.

(2) Exposure of all internal surfaces of equipment to water containing at least 50 ppm of free chlorine for a contact period of 4 hours more, or to water containing at least 100 ppm of free chlorine for one hour or more.

(3) After the required period of contact, reflushing with potable water until the chlorine residual falls to 1 ppm or less.

(b) The lines or equipment will then be ready for use. Bacterial counts should receive attention until it is evident that disinfection has been adequate and other difficulties avoided.

39. Disinfecting Agents.--Free chlorine, purchased in the form of a gas, a compound, or a solution, is the only satisfactory chemical for disinfection of water works. Grade A hypochlorite (HTH or Perchloron) is the most satisfactory as well as the most readily available form for general use. It dissolves easily and contains 65 to 75 percent available free chlorine. One pound in 800 gallons or in 100 cubic feet of water gives a chlorine dose of about 100 ppm. Calcium hypochlorite (chloride of lime) is less easily used and contains only about one-half as much available chlorine per unit weight of compound. Commercially prepared sodium hypochlorite solutions (Chlorox,

Zonite, etc.) may be obtained in 5 and 10 percent strengths. One gallon of 10 percent solution added to each 1,000 gallons of water will give about 100 ppm free chlorine. All hypochlorites raise the p^H of water and thus reduce the effectiveness of the chlorine. This may be of considerable importance if chlorination raises the p^H of the water above a value of 8. For further information on the effect of p^H on the disinfecting power of chlorine see paragraph 52 page . If chlorine gas is used to disinfect mains or equipment, a chlorine feeding device in the hands of a competent operator is required.

40. Decontamination of Wells.--Wells should be decontaminated after construction, cleaning,or removal of equipment for repair. When the well equipment is ready for operation, the well should be flushed by pumping to waste until the water is free of turbidity. A dug well may then be disinfected by pouring in the calculated amount of chemical either in powdered form or as a concentrated solution. Water in the well should be agitated to distribute the chlorine. To overcome the difficulty of mixing the chemical with the water in a drilled well, a volume of 100 ppm solution some 50 percent greater than the quantity of water standing in the hole should be made up in tanks and run down between the riser pipe and the casing.

41. Decontamination of Water Mains.

(a) Careful planning and attention to detail is required in order to properly flush and disinfect underground water pipes. When an entire system must be decontaminated, best results are obtained by isolating and treating consecutive portions of such size that a thorough job may be done with available equipment. The procedure for old mains that have been dewatered for repair, alteration or extension is identical with that used for disinfecting parts of a new system. This procedure should be essentially as described in the following three paragraphs.

(b) Flush the portion of the system to be decontaminated in such a way that velocities of six or more feet per second are maintained in each pipe until water flows perfectly clear. Care must be taken to avoid:

(1) valve manipulations which allow water to flow from contaminated into disinfected portions of the system; and,
(2) flushing in such a manner that dirt and other material which should be removed is merely carried from one place to another within the system.

(c) After thorough flushing, the portion of the system to be disinfected is closed off and filled with highly chlorinated

water. To accomplish this, water from a hydrant on the disinfected system outside the part closed off is chlorinated and fed back through a hydrant on the closed portion. If possible, this feed-back should be to a previously disinfected line included in the closed portion. This overlapping assures disinfection of all parts of the system. The above ground, hydrant to hydrant, connection can be avoided by adding chlorine through a tap just upstream from a gate valve selected for admitting water to the closed system. When chlorinating equipment is in operation and the cross-connected hydrants or the water admitting valves have been opened, chlorinated water is drawn into the closed system by bleeding each hydrant and other outlet until water having a strong chlorine odor appears. If the chlorinating apparatus is set for constant feed, the dosage in ppm will vary inversely with the rate of bleeding from the closed system. Therefore, it is desirable to set the chlorinator to give a dosage rate of 50 to 100 ppm or more when water flows from a single full opened outlet and to bleed one outlet at a time progressively away from the point of chlorination. For accurate control of dosage a water meter must be used either at the point of bleeding or on the feed line.

(d) Flushing after chlorination presents no problem. Poor flushing will be evidenced by complaints of chlorine odor and taste. If possible chlorinated water from a part of the system that has just been disinfected should be used to flush out the next part to be treated, thus conserving water and using the disinfecting effect of the remaining chlorine.

42. Decontamination of Equipment.--All equipment, including pumps, filters, filter regulating equipment, piping, etc., must be thoroughly flushed and disinfected. Since the procedure to use depends on the physical arrangement of the equipment in each particular case, it is not possible to formulate rules that would apply to all situations. The principles outlined in paragraph 38 should be followed.

43. Decontamination of Pure Water Reservoirs and Tanks. It will frequently be impractical to disinfect a large reservoir or tank by filling it with highly chlorinated water. In such cases the tank or reservoir should be flushed or washed down with a strong hose stream and disinfected by swabbing all internal surfaces with a solution containing at least 200 ppm free chlorine.

Section VII.--WATER PURIFICATION--ESTABLISHED BASES

44. Types of Water Purification Plants.--Water is purified on established bases either by simple chlorination or by treat-

ment in a modern filter plant. Simple chlorination is suitable for purification or protection of purchased municipal supplies that may at times be questionable in quality, and for disinfecting clear and relatively high quality water from wells or from mountain streams or reservoirs. Chlorination alone should be used on permanent stations only when the raw water is normally of very good quality. It then provides a safety factor against chance contamination and against breakdown in measures used to protect the source. When the raw water is normally unfit to drink, a filter plant should be provided. The ordinary purification plant includes means for coagulating, settling, filtering,and disinfecting water. In special cases additional processes for softening and demineralization may be required.

45. Raw Water Quality.

(a) In order for purification plants to produce continuously satisfactory water, the raw water pollution must remain within reasonable limits. For plants which provide coagulation, sedimentation, filtration, and disinfection the coliform bacteria in the raw water should not average more than 5,000 per 100 ml. in any month and should not exceed this number in more than 20 percent of samples examined in any month. Waters showing numbers exceeding 5,000 per 100 ml. in more than 20 percent of the samples and not exceeding 20,000 per 100 ml. in more than 5 percent of samples examined during any month require auxiliary treatment. By auxiliary treatment is meant presedimentation or prechlorination, or their equivalents, either separately or combined as may be necessary. Waters containing coliform organisms in excess of 20,000 per ml. in more than 5 percent of the samples examined in any month should be considered as unsuitable for use as a source of water supply unless they can be brought into conformance with the above requirements by prolonged preliminary storage or some other measure of equal permanence and reliability.

(b) In addition to meeting bacterial requirements, the raw water should not contain any toxic or harmful substances, or organisms not readily removed by ordinary water treatment. Raw water should be free of excessive amounts of acid, microscopic organisms or organic matters that might interfere with the normal operation and efficiency of water treatment processes.

46. Plant Capacity.--The filter plant should have a capacity at least 50 percent in excess of the average daily draft.

47. Coagulation and Sedimentation.

(a) The great importance of the coagulation and sedimentation process in a modern water treatment plant is seldom

fully appreciated. This process normally accomplishes at least 70 or 80 percent of the purification and in well designed and operated plants may remove well over 90 percent of the bacteria and suspended matter. The coagulation and sedimentation process has an importance beyond the removal of suspended matter. It is a necessary adjunct to rapid sand filtration. The efficiency of filtration and freedom from filter difficulties depends largely on the degree of clarification obtained in the sedimentation process.

(b) Coagulation and sedimentation consists of the following steps:

(1) Addition of a chemical which reacts with the alkaline constituents in a water to form a gelatinous precipitate (floc) which entraps particles of suspended water.

(2) Rapid mixing (flask mixing) for a period of 1 to 5 minutes to distribute the coagulant through the water.

(3) Slow mixing (flocculation) for about 20 to 30 minutes to permit the floc to grow and to entrain suspended matter and bacteria.

(4) Passage through large tanks (sedimentation) where the floc is permitted to settle. The detention period in continuous flow tanks should never be less than two hours, and preferably should be six hours or longer.

(c) The chemicals suitable for coagulation of water are aluminum sulfate (filter alum), $Al_2(SO_4)_3.18\ H_2O$; ferrous sulfate (copperas), $FeSO_4$; ferric sulfate $Fe_2(SO_4)_3$, ferric chloride, $FeCl_3$; ammonium alum $Al_2(SO_4)_3.\ (NH_4)_2\ SO_4.24\ H_2O$; and sodium aluminate, $Na_2Al_2O_4$. Of these, aluminum sulfate is by far the most widely used. The dosage of alum needed to properly coagulate water usually lies between one-half and two grains per gallon.* Polluted waters may at times require treatment with high doses, 4 grains per gallon or more. Each grain per gallon of alum theoretically requires about one-half grain per gallon of alkalinity to precipitate the aluminum hydroxide floc. If the natural alkalinity is insufficient lime or soda ash may be fed.

(d) The correct dose of chemical to use for the treatment of any water at any time can be determined only by trial and error. In a series of jars, beakers, or bottles, portions of raw water are treated with various doses of coagulant, and after thorough mixing, the size and rate of settling of the floc, and the

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* One grain per gallon equals 17.1 parts per million equals 143 pounds per million gallons.

clarity of the water are observed. The smallest chemical dose that produces a good floc and complete clarification is the correct one to use in the plant. One-half liter samples are convenient for these so-called jar tests. Four milliliters of a solution containing 2.14 grams per liter of filter alum ($Al_2(SO_4)_3 \cdot 18\ H_2O$) added to a one-half liter sample equals one grain per gallon. Using 4 to 8 samples, trial dosages in increments of one-quarter (1/4) or one-eighth (1/8) grain per gallon are obtained by adding multiples of 1 ml. or 1/2 ml. of the above alum solution. A mixing device for use in making jar tests is illustrated in Fig. 5-1.

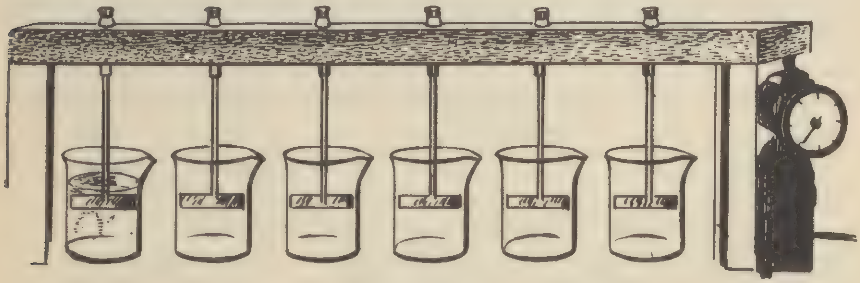

FIGURE 5-1.--MULTIPLE MIXING DEVICE

(e) In processing highly polluted water or that containing materials that impart a strong taste or odor, it may be necessary to use additional treatments prior to filtration. The important supplementary treatments involve one or more of the following:

(1) aeration,
(2) superchlorination followed by dechlorination,
(3) ammonia-chlorine process, or
(4) the use of activated carbon.

(f) In order to insure continuous operation the flocculation and sedimentation basins should be at least two in number. Sedimentation basins not provided with mechanical sludge removal mechanisms must be drained every 4 to 6 months and the accumulated sludge flushed out with strong hose streams.

48. Filtration.

(a) Two types of filters are in use, the slow sand filter and the rapid sand filter. Slow sand filters are large beds of sand through which relatively clear raw waters may be passed, without pretreatment, at filtration rates ranging from 2 to 8 million gallons daily per acre of filter surface. The

schmutzdecke or dirt layer which accomplishes the filtration is a zoogloea built up by natural processes. Slow sand filters are cleaned by the laborious process of scraping off and washing the top layer of sand. Very few filters of the slow sand type have been constructed in the United States in recent years because of their high initial cost and the cleaning difficulties when the raw water contains considerable turbidity. The advantages of simplicity in design and operation favor the use of slow sand filtration for small permanent supplies at overseas stations.

(b) Municipal type rapid sand filters operate at rates of from 2 to 3 gallons per minute (gpm) per square foot of sand area (125 to 200 million gallons daily per acre). Portable pressure filters used in the field may be operated at rates as high as 6 gpm per square foot. Sand beds are normally 24 to 30 inches in depth. The sand used is fairly uniform and of such

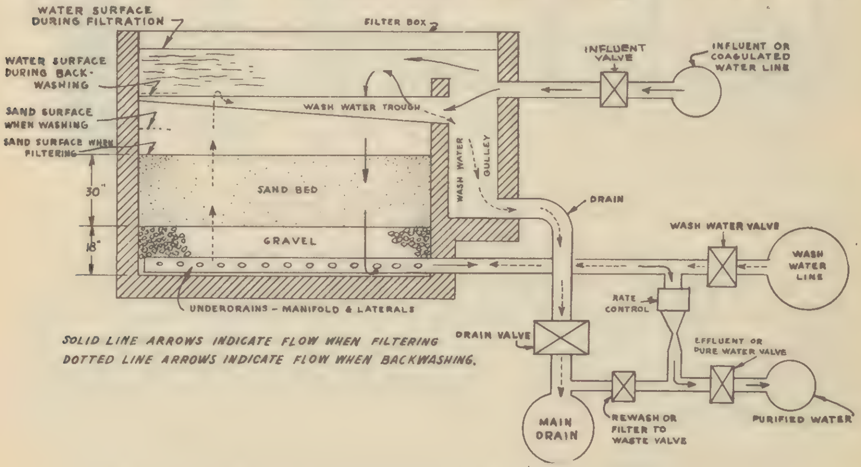

FIGURE 5-2.--CROSS-SECTION OF A RAPID SAND FILTER

size that 10 percent of it is smaller than 0.3 to 0.6 millimeters in diameter. Bacteria and colloidal matter would readily pass sand of this size if it were not for the formation of a coating of aluminum hydroxide floc on and in the surface of the sand bed. Since residual floc carried over from the sedimentation basin serves this purpose, the process of coagulation and sedimentation cannot be dispensed with in a rapid sand filtration plant. There is no need for concern about settling too much of the floc. Enough will always remain to make the filter function. Improved coagulation and sedimentation invariably reduces filter difficulties.

(c) A rapid sand filter, Fig. 5-2, is cleaned by backwashing the bed with purified water. Salient design features are controlled by the backwashing process which requires the uniform distribution of large volumes of water beneath the bed and the collection of the dirty water rising out of the sand. During washing, the sand bed expands some 50 percent and the vibrating grains are suspended in the rising wash water. The scouring action is greatly improved by use of "surface washing." Surface washing is accomplished by high velocity jets issuing from perforated pipes suspended in the filter at such level that they are just beneath the surface of the expanded bed, but hand above the sand after it settles back into place when the back wash is turned off. The following steps are involved in backwashing a filter:

(1) Close the influent valve and allow the water to drain down to or below the top of the gutters.

(2) Close the effluent valve.

(3) Open the drain valve.

(4) Open the wash water valve gradually to prevent dislodgment of the gravel, and when fully open, wash the filter until it is cleaned. A 5 to 10 minute wash is usually adequate. If surface wash is provided, it may be turned on either before or after the bed is expanded but must be shut off before the backwash valve is closed.

(5) Close the wash water valve.

(6) Close the drain valve.

(7) Open the influent valve and when filter box is again filled with water open the effluent valve. The filter is then back in operation. Most filters are equipped with "filter to waste" (rewash) valves and instructions sometimes call for filtering to waste for a few minutes after backwashing in order to permit the floc layer to form on the sand surface and become effective. Filtering to waste has been found to be unnecessary in most plants. Rapid sand filters should be washed when clogged to the point that the filtration rate begins to fall off or when the filtered water begins to show an increase in turbidity. The normal period between washes is 24 to 48 hours. If filters are allowed to operate too long without washing or if the washing process is incomplete, filter difficulties are almost certain to develop. The first evidence of trouble will be the appearance of small mud balls on the surface of the sand. These grow in size until they penetrate the bed during washing and form internal accumulations of mud. A con-

dition is soon reached which requires complete removal of sand and gravel for cleaning and recharging. In order to facilitate proper operation and control, efficient loss-of-head gages, rate controllers and other essential control devices should be provided and maintained in good working order.

49. Filtered Water Storage.--Filtered water is stored in reservoirs called clear wells which are located beneath the filters or near the filter plant. Where they are located below the filters, adequate protection against leakage of water from other parts of the plant into the reservoirs should be provided. Covered reservoirs located near, but physically separated from, the plant are preferred. Trap doors and inspection openings should be properly sealed and locked. Suitable vents protected against outside contamination and screened to exclude insects and rodents should be provided. Filtered water reservoirs should be thoroughly tight against external leakage, should be situated above the ground water table and preferably should have no walls in common with any plant units containing water in the process of treatment.

50. Sanitary Precautions in Filter Plant Design.

(a) No cross-connection or interconnection should be permitted to exist in a filtration plant between any conduit carrying filtered or postchlorinated water and another conduit carrying raw water or water in any prior stage of treatment.

(b) No conduit or basin containing purified water should be permitted to have a common division wall with another conduit or basin containing raw water or water in any prior stage of treatment.

(c) No conduit carrying raw water, water in a prior stage of treatment, or drainage from laboratories, toilets, floors, roofs, etc., should be located in or pass through any conduit or tank containing finished water.

(d) All filter plant drains should be designed to prevent surcharging by flood waters or by drainage water discharged during emptying of tanks, washing of filters, etc. The main filter wash water drain, the clear well drain, and the ground water drain around or beneath the clear well should each be separate and have a separate outlet which receives special attention with regard to protection from flooding. In no case should these drains be connected to a public storm or sanitary sewerage system.

(e) Toilet and laboratory wastes originating within the filter plant should be discharged through a separate sanitary

system so located and designed that there is no possibility of leakage or flooding of these wastes into the water under treatment.

(f) Where possible, filter plants shall be located on high ground above and distant from public sewers and shall be surrounded by well parked and policed areas.

51. Disinfection of Water Supplies.

(a) Water may be disinfected by use of chlorine gas, chlorine compounds, iodine and bromine in various forms, ozone, metallic silver ions, ultraviolet light, heat, etc. Of all known methods, chlorination is the most satisfactory process for disinfecting large quantities of water. Other methods should not be used, except in emergency, without a careful review of the literature to determine their current state of developement. The terms chlorination and disinfection are here used to indicate the same process.

(b) Chlorination includes all processes using chlorine gas or chlorine compounds to produce in the water either of two distinctly different disinfecting agents, free chlorine or chloramines. Which of these predominates depends on the ratio of chlorine dose to the ammonia-nitrogen (ammonia radical expressed as nitrogen). Ammonia may be a natural constituent of the water or may be added. If the chlorine: ammonia-nitrogen ratio is below 5:1, chlorine reacts to form chloramine. Chloramines are destroyed by further increases in chlorine dose until at a chlorine: ammonia-nitrogen ratio of about 9:1 chloramine has been completely oxidized. This point of minimum residual is called the break-point. Chlorine added beyond this point produces free chlorine residuals.

(c) Five methods of chlorine dose control are in use:

(1) fixed dose,
(2) minimum residual after fixed contact time,
(3) minimum residual throughout distribution system,
(4) superchlorination-dechlorination and
(5) break-point chlorination. The type of residual, whether free chlorine or chloramine, obtained using the first three methods of control depends on the chlorine: ammonia-nitrogen ratio. The last two methods give free chlorine residuals.

(d) Free chlorine appears to be about 30 times more effective than chloramines in bactericidal action if the p^H is around 7.0 or lower. At high p^H, it is not. It is, therefore, advisable to distinguish between free chlorine residuals and

chloramine residuals. The ortho-tolidine test as ordinarily used does not do this. However, by reading the flash color, i.e., the color appearing at 10 seconds after addition of the ortho-tolidine, an idea of the free chlorine content of the sample may be obtained. The color after 5 minutes measures the sum of free chlorine, chloramine, and interfering substances. Temperature of the sample should be below 60 ° F.

(e) The p^H value of water has a marked effect on the bactericidal action of both free chlorine and chloramines. Their effectiveness decreases so rapidly with increasing p^H that under some conditions it may be better to lower the p^H than to add the excessive doses of chlorine required at high p^H values. The latter has been considered, though not adopted, in connection with super-chlorination using hypochlorites. Large doses of hypochlorites materially increase the p^H value.

52. Control of Chlorination.

(a) The following rules are suggested as safe guides in the control of chlorine dosage:

(1) Apply chlorine continuously at a point where thorough and rapid mixing with the treated water will be effected, or in batch chlorination mix by thorough stirring.

(2) Differentiate free chlorine and chloramine residuals.

(3) If the residual is free chlorine and the p^H is below 7, chlorinate to obtain 0.2 ppm free chlorine residual after 20 minutes contact. Increase this residual 0.1 ppm for each increasing p^H interval above 7, i.e. for p^H 7 to 8 maintain 0.3 ppm and 8 to 9 use 0.4 ppm residual. Keep the p^H below 9.

(4) If the residual is chloramine and p^H is below 7, chlorinate to obtain 1.0 ppm chloramine residual after 2 hours' contact. Increase this residual 0.5 ppm for each increasing p^H interval above 7; i.e. for p^H 7 to 8 maintain 1.5 and for p^H 8 to 9 maintain 2.0 ppm chloramine residual. Keep the p^H below 9.

(5) If it is desired to use break-point chlorination, meet or exceed the minimum requirements under (c) above and impose the additional requirements that 85 to 100 percent of the residual be free chlorine.

(b) Where bacteriological tests indicate that the above minimum requirements are inadequate a residual of free chlorine of 0.1 to 0.2 ppm may be maintained throughout the distribution system, in which case chlorination at the plant is regulated to provide the desired residual at distant points in the distribution system. In no case should the maintenance

of residuals in the distribution system be looked upon as a satisfactory substitute for proper sanitary protection of the water during distribution.

(c) If chlorination is to be depended on to kill the cysts of endamoeba histolytica, high free chlorine residuals must be used. The following should be adequate. For pH values below 7 chlorinate to maintain a free chlorine residual of 3 ppm after 20 minutes' contact. For pH 7 to 8 maintain an 8 ppm residual after 20 minutes' contact and for pH 8 to 9 use sufficient chlorine to give a residual of 18 ppm free chlorine after 20 minutes. Since hypochlorites have a marked effect on the pH of some types of water, it may at times be better to lower the pH with an acid than to add more hypochlorite. Dechlorination of the water is necessary when the high residuals suggested in this paragraph are used. Treatment by coagulation, sedimentation, and filtration is advisable when cyst contamination is suspected. With adequate pretreatment and filtration, the usual doses of chlorine are probably adequate.

(d) The cercariae of Schistosomiasis are not entirely removed by filtration but are killed by chlorine doses used overseas. Chloramines appear to have about the same cercaricidal effectiveness as free chlorine. One part per million residual after 30 minutes of either free chlorine or chloramines is adequate.

53. Chlorination Equipment.--Chlorination equipment should be selected, installed and operated so that continuous and effective disinfection is obtained at all times and so that the hazard of using chlorine gas is minimized. The following requirements should be met:

(a) Chlorination equipment should have a minimum capacity at least 50 percent greater than the highest expected rate of feed.

(b) Automatic proportioning of rate of chlorine feed to rate of water treated should be provided at all plants where the flow varies more than 50 percent from the average. Manual control should be permissible only where the rate of flow is relatively constant and an attendant is always at hand to effect promptly any necessary adjustments in dosage.

(c) All chlorination equipment should be installed in duplicate to insure uninterrupted operation. Duplicate units should be operated frequently to assure workability. A complete stock of spare parts and tools should be maintained for emergency replacements and repairs.

(d) Chlorination equipment should be capable of satisfactory operation under every condition at the plant. A supply of water,

free of coarse suspended matter, should be available under adequate pressure to insure the continuous operation of solution feed chlorinators. Alternative sources of power for maintaining this pressure should be provided where necessary to insure continuous operation.

(e) Scales, preferably of the recording type, should be provided for weighing cylinders of chlorine in order to obtain loss of weight figures for checking the rate of feed setting on the chlorinators.

(f) A sufficient number of cylinders of chlorine should be connected to chlorinators in use to assure adequate operating pressures at all times.

(g) A sufficient stock of chlorine gas or chlorine compounds should be on hand to preclude any danger of exhausting the supply of chlorine.

(h) Hypochlorite solutions should be prepared in a separate mixing tank, then diluted and allowed to settle so that only clear liquid is withdrawn to the solution storage tank which supplies the chlorinator.

(i) The strength of hypochlorite solutions should be checked frequently and should be renewed as frequently as necessary to maintain them at satisfactory strength for accurate control of chlorination.

(j) Chlorinators for feeding gas, and cylinders of chlorine should be housed above ground in special rooms provided with exhaust fans that can be set in operation from outside the room and provided heating, and if necessary cooling, facilities to maintain temperature above 60° F. but below maximum outside summer temperatures. Heat shall never be applied directly to chlorine cylinders.

(k) Suitable gas masks and a bottle of ammonia for testing for leaks should be kept immediately outside of rooms in which chlorine gas is stored or used.

54. Operation and Laboratory Control.

(a) Every water purification and disinfection plant should be under the charge of a technically trained supervisor. Plants treating variable or highly polluted raw waters should have continuous and full time trained supervision. Under some conditions small plants may be left in the hands of attendants or operators who lack scientific training but who have been instructed in the mechanical operation of equipment. In such plants the supervisor should be in constant touch with plant attendants. He should be on call in any emergency and should visit the plant as often as is necessary to assure the safety of the water.

(b) For the ordinary filter plant the minimum schedule of laboratory tests should include determinations of turbidity, color, alkalinity, p^H, hardness, bacterial counts, coliform bacterial numbers, residual chlorine and, where coagulation is used, jar tests to control the dosage of coagulants. The frequency of tests required for proper operation control of a filter plant depends on the character of the water treated and on its variability. Bacterial counts and coliform tests on the raw and finished water should be made daily. Turbidity and chlorine residuals in the finished water should be determined hourly.

55. Judging the Efficiency of Operation.--In judging the efficiency of operation of a water plant the following important items should receive consideration:

(a) Training and experience of supervisor and operating staff.

(b) Adequacy of operation records.

(c) Efficiency of laboratory control.

(d) Suitability of plant design to the character and pollution of the raw water.

(e) Capacity of plant in relation to the average and maximum required output.

(f) Freedom of plant from sanitary defects. (See paragraph 50 and Section IX).

Section VIII.--WATER PURIFICATION--FIELD AND ADVANCED BASES

56. Quality of Field Supplies.

(a) The essential qualities to be sought in water supplies for military purposes in the field are (1) safety for drinking, cooking, and washing; and (2), palatability. It is imperative that the water be free of pathogenic organisms and toxic chemicals but it is not to be expected that the quality of water furnished in the field shall always be of the high standards demanded by civilian communities as regards appearance and palatability. The military situation, the needs of the moment, the difficulties of transportation, and the sources available determine the type of treatment procedures that must be used.

(b) The selection of sources is discussed in Section II of this chapter. The quality of rainwater sources must be protected by preventing contamination of the catchment surfaces and by properly storing the collected water. Wells should be up the slope and as distant as reasonably possible from latrines, soakage pits and other waste disposal facilities. Wells are most frequently contaminated by surface water which flows down the

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well itself. Therefore, wells must be wired off, good surface drainage provided, the casing or cribbing sealed into the hole with clay or cement, and the cover and upper end of the drop pipe or casing made water tight. Water should be withdrawn from surface streams above or as distant as possible from camps and villages in the area. In bivouac along a stream or at a watering point the water should be taken or used for various purposes in the following order:

(1) drinking and cooking,
(2) watering animals,
(3) bathing,
(4) washing clothes, and
(5) washing vehicles.

Flags and signs should indicate the zones of use. Sea water should be drawn from beach wells or off shore from the beach at points distant from busy harbors, and from places where wastes are disposed of.

(c) Care must be taken that water rendered safe for use is not recontaminated after purification. Dangerous contamination can be introduced by careless handling or by dipping water from cans with unclean receptacles. When free chlorine has disappeared from a disinfected water, contamination introduced thereafter will not be destroyed. Consequently, in judging the safety of water it is necessary to investigate the quality of the water,

(1) at the source,
(2) after treatment, and
(3) at the point of use.

(d) In the field special attention should be given to the following precautions:

(1) Regard all water as contaminated unless proved otherwise.
(2) Do not permit the use of any unauthorized source.
(3) Indoctrinate all hands in the importance of protecting the quality of drinking water.
(4) Place guards at points where carelessness might result in serious water contamination.

57. Canteen Treatment.

(a) Disinfection of water in canteens may also be accomplished by use of tincture of iodine, Halazone tablets,

Chlor-Dechlor units, iodine tablets, sodium hypochlorite and by boiling.

(b) To use tincture of iodine add two or three drops of a 7 percent iodine solution to a canteen full of water. Wait 30 minutes.

(c) Two Halazone tablets, 4 milligram (1/16 grain) are required to sterilize one canteen of clear, clean water. If a high organic matter content is indicated by turbidity or color (brown water) four tablets should be used. In either case wait 30 minutes before drinking.

(d) Chlor-Dechlor units contain sufficient halazone powder to dose a canteen full of water with about 15 ppm of chlorine and a sodium sulfite tablet which will reduce this amount of chlorine. The sodium sulfite tablet is coated to keep it from going into solution until sufficient time has elapsed for the chlorine to disinfect the water. To use Chlor-Dechlor add the entire contents of one vial to a canteen full of water, screw the cap on loosely, shake gently by rotating for 30 seconds to dissolve the Halazone, WAIT TWENTY MINUTES for disinfection, then shake again to dissolve the Dechlor tablet which removes the residual chlorine. These units have been found to lose strength rather rapidly, and old supplies should not be trusted without testing.

(e) The 0.5 gram Lyster bag tube of Grade A hypochlorite may be used to disinfect water in canteens. Add contents of one tube to a full canteen of water and mix well. Add one canteen cap (6 ml) of this solution to each canteen of water. Wait 30 minutes.

(f) When disinfecting chemicals are not available, the water should be sterilized by boiling for at least three minutes. It is often difficult for the individual to boil water, so when boiling must be resorted to the possibility of using large containers and assigning someone to boil water for a group of men should be considered. Tea leaves or ground coffee may be provided to improve the palatability of boiled water and to encourage the boiling operation.

58. Kit-Type Filter for Canteen Supplies.--The kit-type filter, which is about 6 inches in diameter and 3 inches high, is designed to pump and filter water directly into canteens where treatment with Chlor-Dechlor or other disinfecting agent completes the purification. It can produce potable water from a highly turbid source and has sufficient capacity to fill the canteens of a whole platoon is less than an hour. The kit-type filter is designed for use in situations where small units must depend on immediately available sources of water supply. It

is now a standard item of equipment for Marines and Construction Battalions.

59. Lyster Bag Treatment.

(a) Companies or smaller units disinfect water in Lyster bags (see Fig. 5-3) when in bivouac and not supplied with purified water. In view of the difficulty in preventing recontamination of purified water during handling and transportation

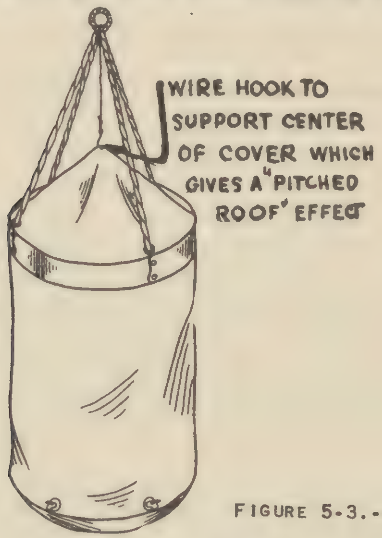

FIGURE 5-3.--LYSTER BAG

in the field, it may be a good idea to disinfect all water in the containers from which it is dispensed for drinking, regardless of whether it has or has not been previously purified. The technic for disinfecting water is as follows:

(1) Empty the contents of four glass tubes of Grade A hypochlorite (0.5 grams each) into a canteen cup half full of water and stir to dissolve. Pour this solution into a Lyster bag full (36 gallons) of water. Stir the water with a clean stick or paddle to insure distribution of chlorine throughout. Draw one-half canteen cup of water from each faucet and pour it back into the water bag. This disinfects the faucets.

(2) Allow a twenty-minute contact period and then test for 3 ppm residual chlorine as directed on the ortho-tolidine test kit. The test is made by filling the vial up to the color band, then adding an ortho-tolidine tablet and shaking to dissolve. After a few minutes the color of the sample is compared with that of the colored band. An orange or yellow color darker than the yellow band indicates more than 3 ppm residual chlorine. The orthotolidine color

develops slowly in cold water. Warming the vial in the hand hastens the reaction.

(3) If the solution is a lighter yellow than the color band, there is less than 3 ppm residual chlorine. In this case dissolve one more tube of hypochlorite in a little water and add to the Lyster bag. After 20 minutes, test again for 3 ppm residual. See paragraph 52.

(4) When the water in the Lyster bag has shown a residual chlorine of 3 ppm or more after 20 minutes contact, add the dechlorination solution made by dissolving 4 sodium sulfite tablets in a canteen cup half full of water drawn from the Lyster bag. After agitation the water will be dechlorinated and ready for drinking. Since the water does not contain residual chlorine, it must be carefully protected from recontamination.

(b) Water may be disinfected in Lyster bags by using two canteen caps full of tincture of iodine (7 percent) to one Lyster bag full (36 gallons) of water. Water may be boiled in GI cans and, after cooling, poured into Lyster bags for dispensing. The palatability of boiled water is improved if after cooling it is aerated by stirring or by pouring from one container to another.

(c) Disinfection of water in other containers, such as water cans, drums, water carts, or various types of storage tanks, may be accomplished by the application of a proportional amount of Grade A hypochlorite. For containers of moderate size, i.e., not more than 100 gallons capacity, the Lyster bag method of superchlorination-dechlorination may be used. For larger containers bulk Grade A hypochlorite would normally be used to obtain chlorine residuals after 30 minutes of around 1 ppm and dechlorination would not be attempted.

60. Water Supply Equipment.--Water purification equipment is supplied to the field for carrying out any combination of the following processes: hypochlorination, chemical coagulation, settling, filtration, and distillation. Equipment for developing a water system includes well drilling rigs, well pumps, centrifugal pumps, pipe, valves, fittings, and steel and canvas storage tanks. Detailed instructions for erection, operation, and maintenance are furnished with each piece of equipment. For descriptive material in addition to the given below, see Bureau of Yards and Docks Pamphlet "Water Supply Equipment Available to Advanced Base Units."

61. Hypochlorination.

(a) The portable automatic hypochlorination unit is designed to treat continuous, flows of 2 to 100 gallons per minute

(gpm) of water with a solution of Grade A hypochlorite. By a simple change in the mechanism it can treat up to 400 gpm. Since dechlorination of large volumes of water is not practical in the field, these units are ordinarily set to produce a 1 ppm residual chlorine after 20 or 30 minutes. Simple chlorination to obtain residuals of about 1 ppm will produce safe drinking water from raw water that is clear and free of amebic cysts. Water that is liable to be contaminated with amoebic cysts must be treated by either filtration or superchlorination. If in areas where amebic dysentery is endemic and where filter capacity is inadequate, simple chlorination may be used to treat wash, bath, and laundry water supplies while the drinking and cooking water alone is filtered. The chlorination unit is also used to disinfect water produced by distillation units. The portable unit consists of a hydraulically operated hypochlorinator, water meter, pressure regulating valve, and a range adjusting valve. The rate of chlorination can be manually or automatically controlled.

(b) Where the hypochlorination unit is not available, chlorination can be carried out by the batch method in storage tanks or other containers. The chlorine solution should be put in the tank or container early in the filling operation in order to obtain adequate mixing.

(c) It is very important that chlorine residuals be checked frequently in the field, at least hourly, during the operation of hypochlorinators.

62. Coagulation, Sedimentation and Filtration.

(a) Coagulation and sedimentation should always precede filtration of water through field type filters. In the past, field filters have been issued for use without sedimentation. These units were not highly efficient in removal of bacteria and amebic cysts and were subject to rapid clogging and attendant operating difficulties when filtering turbid waters or those containing algae growths. The early field type portable filter plant consisted of a chemical treatment unit and a filter unit. Two 3,000 gallon canvas tanks are now furnished to be used with this equipment for sedimentation by the "fill and draw" or "batch" method.

(b) The pump and treatment unit was designed for use when pumping chemically treated water directly to the filter. Since sedimentation tanks are now provided, this combined pumping and chemical dosing unit may be omitted. It is possible to replace this by a simple pumping unit, in which case chemicals are added directly to the sedimentation tank, and a hypochlorinator or batch chlorination can be used to disinfect the water. Chemicals may be added by use of the treatment unit

if it is available or in its absence by either of two methods. (1) making up solutions containing the chemicals required to treat one tank of water and allowing these solutions to trickle into the tank as it fills, or (2) placing the chemicals for one batch in wire baskets which are hung in the tank where the circulating water will completely dissolve the chemicals during the filling operation.

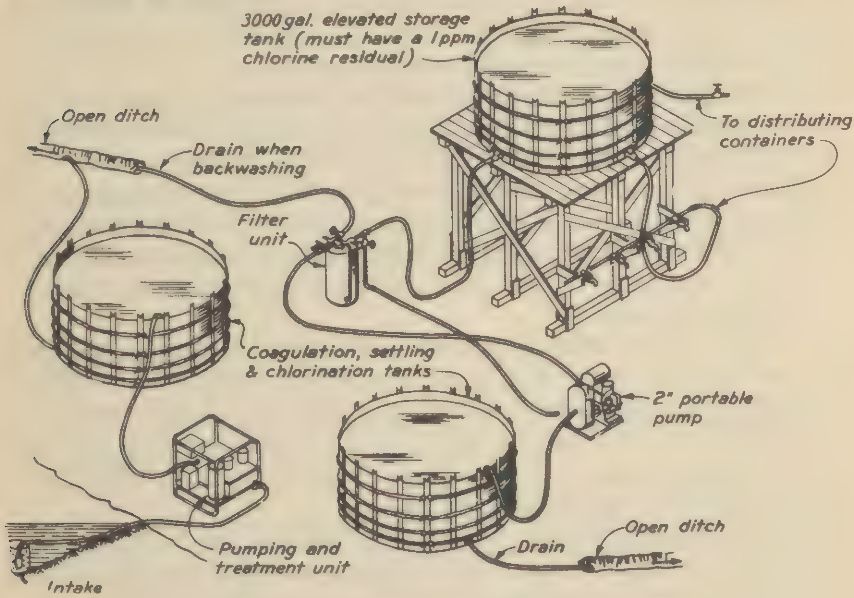

FIGURE 5-4.--LAYOUT OF PORTABLE FIELD WATER PURIFICATION UNIT

(c) The layout of a portable water purification plant is shown in Fig. 5-4. Assuming the treatment unit is used as shown in this figure, the coagulation, settling, and filter operating procedure should be about as follows:

(1) The pump suction is rigged in the source in such manner that mud will not be sucked up and trash will not clog the strainer. The pump discharge hose is placed on the bottom of one of the treatment tanks, directed so the water will swirl in the tank as it fills. The exact amounts of chemicals needed to treat one tank (2,500 to 3,000 gallons) of water are placed in the feed pots and the chemical feed valves are set so that the entire contents of the pots are dissolved during the period required to fill the one tank. The hypochlorite tank is filled and the hypochlorinator set to maintain one part per million chlorine residual in the water after it has been filtered (see paragraph 5). Raw water is then pumped at a rate of around

50 gallons per minute into the tank. The filling will require about one hour.

(2) When the tank is filled, the pump is shut off, and the floc and clarity of the water is observed. If coagulation is good, the water near the surface should be almost crystal clear after a short settling period. If coagulation is poor, check the p^H and if below 6.0 add soda ash; in any case add more alum directly to the tank contents and stir the chemicals in thoroughly with a paddle.

(3) While the first tank settles, the second tank is filled and settlement started. The chemical doses are adjusted as need therefor, is indicated. The proper amount of chemical is placed in the feed pots each time and alternate batch treatment is continued. The first batch need only be settled for an hour or two. Subsequent batches will have about four hours to settle while the alternate tank is being emptied.

(4) Water which has been treated and settled is pumped through the filter unit into the storage tank at a rate of not more than 10 gallons per minute. For the 18 inch diameter filter this amounts to a filtering rate of about 6 gallons per square foot per minute or about double the maximum rate used in municipal plants.

(5) Water may be drawn from the settling tank in either of two ways. By the first method the suction hose of the filter pump is carried over the side of the tank and the inlet is suspended just below the water surface. The inlet must be lowered from time to time to follow the receding water level and the pump stopped shortly before sediment on the bottom of the tank would begin to be sucked up. The second method is to attach the pump suction to the tank drain line and pump from the bottom of the tank wall. This method is successful because the swirling of the tank contents during filling piles the settled suspended matter in a cone at the center of the settling tank where it remains undisturbed when water is drawn at the tank wall. If the filtering rate is properly regulated it should require 5 to 6 hours to draw the clarified water from one tank.

(6) The sludge or floc may be flushed from the tank after settling each batch or may be allowed to accumulate for a day or two between flushings. Coagulation is often improved and the amount of chemical needed is reduced by allowing some accumulation of sludge. This sludge

will be stirred up during each filling of the tank but will produce very rapid settling.

(7) The filter should be backwashed with purified water after each 24 hours of operation or more frequently if necessary to maintain the filter rate. Care must be taken to avoid washing sand out of the filters. To this end the dirty wash water should be sampled and observed for the presence of sand. Regular washing at the specified intervals will reduce the tendency to loose sand. Filter tanks must be initially filled by admitting water slowly to the bottom of the tank until all air is displaced from the sand and tank. If this is not done the filter will not work properly and sand will be blown from the tank during the first attempt to backwash. Periodical inspections should be made to see that the filter tank actually contains the proper quantity of sand.

(d) Either of two types of alum are supplied for coagulation of water in the field:

(1) filter alum ($Al_2(SO_4)_3 \cdot 18H_2O$) which is the type used in municipal filter plants and,

(2) ammonium alum ($Al_2(SO_4)_3 \cdot (NH_4)_2 SO_4 \cdot 24 H_2O$) which is used for pot feeders when the sedimentation process is omitted. Ammonium alum was used only because of its slow solubility rate when pot-feeding chemicals directly to the filter. The chemical is much more expensive than filter alum, and 1-1/2 to times the weight is required to coagulate water satisfactorily. The slow solubility rate of ammonium alum is actually a disadvantage when coagulation and sedimentation is used as described in paragraph 3, page . Therefore, although ammonium alum can be used, filter alum is on all counts the chemical of choice. The discussions of chemical dosages in the following paragraph refer to filter alum. If ammonium alum is used, about double the stated quantities or weights should be used to obtain equivalent coagulating effect.

(e) Quantities of chemical needed will vary with the water encountered. A 3,000 gallon tank will normally require about three-quarters of a pound of filter alum but requirements may vary from one-half up to twice this amount. One feed pot on the portable treatment unit holds about one and one-half pounds when loosely filled to near the top. Soda ash ($Na_2 CO_3$) to react with the alum is usually not required in waters that have appreciable natural alkalinity. When waters of low alkalinity are

encountered, soda ash may be needed in amounts equal to one-quarter to one-half the amount of filter alum used. If all the alum placed in the feed pot or pots does not go into solution during the filling of one tank, break or crush the lumps to less than one-quarter inch in size. When starting up the treatment plant, the hypochlorinator should be set to give a three part per million chlorine residual in the settling tank during filling. After the filter is started, the residual in the filtered water should be checked and the chlorination of subsequent batches adjusted to provide a residual of one part per million in the filtered water storage tank.

(f) Since the quantity of coagulant and of chlorine is different for different waters and since the required dosages may vary widely with a single source as the raw water quality changes during and after heavy rainfalls, it is desirable to conduct periodically, "jar" or "bottle" tests to determine the proper amounts of chemicals to be used. Several samples of the raw water are treated with various amounts of the chemicals made up in solutions of known strength in order to determine the smallest dose that will produce good clarification or give the desired chlorine residual as the case may be. Stirring should simulate that in the plant. Chemicals are conserved and operations improved by using this procedure. See paragraph 47 (4).

(g) The above discussion has been confined to operation of the 18-inch sand filter with preliminary coagulation and "batch" sedimentation. Other field units of various sizes should be operated in a similar manner. The important principles to be followed may be summarized as follows:

(1) Coagulate and settle the suspended matter before passing the water through the filter.

(2) Do not operate sand filters at rates in excess of 6 gallons per square foot per minute.

(3) Wash the filter after every 24 hours of operation or more frequently as necessary.

(4) Use care to avoid washing sand from the filter and check the filter tank occasionally to see that it contains sand.

(5) Maintain a chlorine residual of one part per million in the filtered water.

(6) Where possible control operations by treating raw water samples by trial dosages of the various chemicals.

63. Diatomite Filtration.--Diatomite filters may be substituted for sand filters. The diatomite filter tank houses vertically mounted porous cylinders on which is deposited the diatomaceous earth filter bed. The initial layer of diatomite, the precoat, is applied by recirculating a suspension of diatomaceous earth. Filtration is then started and a small amount of diatomite, the body-feed, is added continuously to maintain the permeability of the filter bed. When the filter becomes clogged after a few hours, the diatomaceous earth cake is backwashed off the cylinders and the operation repeated using fresh material. If the raw water is turbid, filtration should be preceded by coagulation and sedimentation. Diatomite filters are smaller and lighter than sand filters of the same capacity but this advantage is offset by the need for supplying the filter aid. When carefully operated these filters produce a high quality water. A failure in the supply of diatomaceous earth would render the filter useless.

64. Distillation.

(a) Distillation units are provided for use where fresh water sources are not available. Single and double effect units were first supplied to the field in 2,000 gallons per day and 5,000 gallons per day sizes. These units have a distillate-fuel ratio of about 20 to 1. The new vapor compression distillation units now provided have a distillate-fuel ratio of 150 to 1. These have capacities of around 1,700 to 3,000 gallons per day and weigh about half as much as the single and double effect distillation outfits per unit of output. The principal disadvantages of distillation are large fuel consumption, high cost, bulkiness of equipment, and the need for highly trained personnel for operation and maintenance.

(b) When distillation is used ashore, rigid control of the use of water should be exercised. The allowance of water should not be over 10 gallons per man and preferably not over 5 gallons per man per day. Development of rainfall as a source of water should supplement a distilled water supply and brackish well water should be used for laundry and bathing. It is recommended that well points be used to draw the least brackish water available for distillation and that the equipment be protected from sediment and sand by use of plain settling.

(c) When operating perfectly the distillation process should destroy or remove all organisms. However, experience has shown that it is necessary to disinfect the distilled water whenever the source of supply is contaminated.

65. Taste and Odor Removal.

(a) Taste and odor is ordinarily caused by high organic content or by contamination of the water with oil or other

waste products. Odors which are faint or unobjectionable in the raw water may be greatly accentuated by chlorination. Many of the odors which cause complaint against too much chlorine are, in fact, due to reaction products of chlorine and other substances in the water. Free chlorine itself does, however, impart an objectionable taste and odor when present in amounts exceeding a few tenths of a part per million.

(b) The best solution of a taste and odor problem is to seek a source which is free of organic matter or other troublesome substances. If this cannot be done there are two types of treatment that may be practical for field use: aeration, and treatment with activated carbon.

(c) Aeration can be accomplished most easily by spraying the water into the air above the pure water storage tank. Carbon dioxied, hydrogen slufide if present, and the volatile odorous compounds will escape to the atmosphere. Aeration not only reduces odors but improves the palatability, especially of distilled water, by adding oxygen. The effectiveness of the process depends on the fineness of the spray and its time of contact with the atmosphere. Aeration seldom removes all taste and odor and in many instances may be altogether ineffective.

(d) Activated carbon is simple to use and is highly effective in removing tastes and odors. Since it is a strong dechlorinating agent, it must be applied at a place where disinfection will not be interfered with. In field purification plants, activated carbon will have to be added either in the settling tanks or in the pure water storage tank. If added to the sedimentation tank, the water must be chlorinated after filtration rather than at the time coagulants are added. On the other hand, when water is chlorinated before sedimentation, the activated carbon must be added to the pure water storage tank, in which case the residual chlorine will be removed as well as tastes and odors. This is all right so long as the water is well protected from recontamination. The use of small amounts of carbon in the purified water will be neither objectionable nor harmful. The amounts of powdered activated carbon required to remove all taste and odor from a 3,000 gallon tank full of water ranges from about one-quarter pound up to two pounds. One-half pound to the tank should normally be sufficient. The powder should be wetted and thoroughly mixed with a small amount of water, then added when the tank is one-half to two-thirds filled in order to obtain adequate mixing.

66. Sanitation of Water Container.--All drinking water containers and equipment must be kept scrupulously clean and should be periodically sterilized with boiling water or with a strong chlorine solution (100 to 200 ppm). Canteens, cans,

carts, barrels, barges, and all hoses and fittings used for handling drinking water must be kept free of dirt and filth and sterilized as necessary by allowing them to stand full of a strong chlorine solution for several hours. The use of canteens to carry milk, fruit juices, etc., should be discouraged because of the difficulty in removing the dried residues of these materials from canteens. Do not attempt to clean canteens and the like with sand or pebbles unless facilities are available for immediate and thorough sterilization. For additional information see Section VI of this chapter.

Section IX.--SANITARY DEFECTS IN WATER SYSTEMS

67. Sanitary Surveys.

(a) Sanitary surveys are detailed investigations to locate actual or potential sanitary defects. They may be in the nature of an examination for diagnosis of an illness or they may serve a purpose similar to that of an annual physical examination. Sanitary surveys include any or all of a wide variety of procedures for obtaining both direct and circumstantial evidence concerning conditions which are or may become dangerous to health. Thus such surveys are more than inspections; they are critical studies of all phases of water procurement, treatment, and distribution, and may involve review of the records, special field tests, taking of testimony all supplemented by epidemiological and laboratory studies to establish the facts.

(b) A sanitary defect is any structural condition, whether of location, design, or erection, or any construction or operation practice which may regularly or occasionally cause the water supply to be contaminated from an extraneous source or fail to be satisfactorily purified. When routine bacteriological tests show organisms of types or in numbers that should not be present, an immediate search for the sanitary defect must be made. A considerable departure from accepted standards may demand adoption of emergency sterilization or discontinuance of use until the failure in sanitation has been discovered and corrected. The discovery of the existence of sanitary defects is the pay-off on all routine water laboratory work.

(c) The common failures or deficiencies in water sanitation on shore stations are listed in the following paragraphs for use in locating defects when making sanitary surveys. The sanitary defects are classed according to place of occurrence as follows:

(1) laboratory,
(2) wells,

(3) pumping stations,
(4) filter plants,
(5) disinfection process,
(6) storage reservoirs,
(7) distribution systems, and
(8) plumbing systems.

(d) When the sanitary defect involves contamination by leakage of polluted surface or shallow ground water into wells, underground pipes, tanks, etc., the "dye" or "salt" method of tracing flow to establish the mode of contamination proves very useful. The dyes fluorescein and eosin are best for the purpose. When dissolved in water fluorescein appears, by reflected light, a brillant green. It can be detected by the unaided eye in dilutions of one part in 40 million and with the aid of a long glass tube, in dilutions of one in 10 billion. A concentrated solution of the dye is poured into the place from which the flow is to be traced and samples of water at the suspected point of contamination are observed for the appearance of the dye. Strong solutions of common salt may be used in the same way, in which case titrations or conductivity tests for chlorides must be made. The salt method is usually less sensitive than the dye method.

68. Laboratory Errors.

(a) Sometimes bacterial densities higher than expected result from difficulties in the laboratory. Check samples should be run whenever counts are high in order to confirm results as well as to provide evidence which may lead to discovery of the sanitary defect. Vigorous prosecution of a field search for the source of trouble should not be delayed while laboratory results are confirmed unless there is definite evidence that the laboratory is at fault.

(b) Difficulties in the laboratory which may result in high bacterial counts are:

(1) failure to collect sample properly,
(2) improper protection of sample during transportation to the laboratory,
(3) failure to analyze the sample within a reasonable time after collection,
(4) improper sterilization of equipment,
(5) improper laboratory technic, and
(6) faulty culture media.

Certain of these difficulties produce results which may be

either much lower or much higher than the true bacterial densities.

69. Defects in Wells.

(a) Improper sterilization of the well or well equipment either when first installed or following repairs.

(b) Presence of caves, crevices, sink holes, or abandoned wells or borings open to surface drainage or sewage in the vicinity of the well. Common defect in limestone, coral, and volcanic areas.

(c) Casing of tubular wells leaky, not extended above ground or above floor of pump room, not closed at top, or casing improperly used as suction pipe.

(d) The annular space between the casing of tubular well and the wall of the hole not properly sealed to prevent flow of surface water or shallow ground water down outside the casing. A common defect.

(e) Collecting well or reservoir, or the pump floor subject to backflow of polluted water or sewage through improper drainage. Never drain parts of a water system into a sewer that may be subject to clogging and flooding.

(f) Source of supply or structures subject to flooding during periods of heavy rainfall.

(g) Leaks in gravity lines or in suction pipes permitting entrance of polluted shallow ground water.

(h) Cross-connection between well equipment and a sewer or secondary water supply.

70. Pumping Station Defects.

(a) Leaky underground suction lines.

(b) Suction well or reservoir not protected from subsurface pollution.

(c) Suction well, pump floor, etc., subject to pollution by backflow through improper drain.

(d) Flooding structures and equipment during high water.

(e) Contamination of lines and equipment when dismantled for repair and failure to properly sterilize after reassembly.

(f) Cross-connections with a sewer or secondary water supply.

(g) Unsafe water used for priming pumps.

71. Filter Plant Defects.

(a) Excessive raw water pollution in relation to the extent of treatment provided.

(b) Existence of nearby uncontrolled sources of raw water pollution.

(c) Deficient output capacity or poorly designed equipment resulting in overloading and improper functioning of treatment plant.

(d) Improper separation of conduits or treatment tanks and other devices thus permitting leakage of raw or partially treated water into more highly treated or completely treated water.

(e) By-pass connections or cross-connections by which raw or partially treated water may be short circuited through the plant.

(f) Lack of competent supervision and operation.

(g) Inadequate laboratory control of deficient or inaccurate laboratory records.

(h) Cross-connections with sewer or secondary supplies, toilet and laboratory drains passing through or over treatment tanks, improper drainage of tanks or equipment permitting backflow of sewage or polluted water, etc.

72. Disinfection Process Defects.

(a) Capacity of chlorination equipment inadequate to meet emergency needs.

(b) Duplicate chlorination equipment not available.

(c) Insufficient or improper supervision and control of chlorination.

(d) Failure to make frequent checks of chlorine residual resulting in failure to adjust chlorine dosage immediately when the chlorine demand of the water or the rate of flow changes suddenly.

(e) Failure to keep an adequate supply of chlorine or chlorine compound on hand at all times.

(f) Failure to make up fresh chlorine solution as frequently as necessary, when hypochlorination is used.

(g) Inadequate mixing and contact of water and chlorine especially where waters from several sources, some chlorinated and some not, are discharged into a single reservoir.

(h) Inadequate contact period and inadequate residual when chlorine treatment is used.

(i) Any interruption, from whatever cause, in the maintenance of a uniform and continuously adequate chlorine residual in the treated water.

73. Storage Reservoir Defects.

(a) Inadequate protection of surface reservoirs from inflow of shallow ground water or surface drainage.

(b) Inadequate protection of open filtered water reservoirs, from pollution by individuals, e.g., illicit night bathing in reservoirs, picnicking or in other ways using reservoir margin as a park, etc.

(c) Willful contamination of water in reservoirs as an act of sabotage.

74. Distribution System Defects.

(a) Existence of fixed cross-connections between the potable supply and secondary supplies of questionable safety at any point in the distribution system.

(b) Cross-connections between the fire and flushing system aboard ship and the potable water supply ashore, with the ship then pumping polluted harbor water into the shore distribution system. Many instances of this have occurred. Specially threaded connections may be used to prevent unauthorized personnel making ship to shore water connections.

(c) Failure to properly flush and sterilize new water mains or water mains that have been open for repair. Use of fire hoses, without prior sterilization, for potable water connections.

(d) Intermittent service or heavy draft causing vacuum in system, in which case,leakage is into the distribution system rather than out of it.

(e) Connections to sewers and sewer flushing chambers either for flushing the sewer or for emptying or flushing the water mains.

75. Plumbing System Defects.

(a) Flushometer toilets without vacuum breakers.

(b) Water connections to galley and scullery equipment, laboratory and hospital equipment, etc., in which an adequate air gap has not been installed.

(c) Cross-connections with unsafe auxiliary supplies on the premises of the consumer.

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Chapter 6

Water Supply Afloat

Section I.--SHIP'S WATER SUPPLY

1. Water Systems.--Naval vessels have two primary water systems which serve the entire ship, the fresh water storage and distribution system and the fire and flushing system. Independent systems supply water for boiler feed, distiller circulating and evaporator feed, and other special engine room uses.

2. Quality of Water.

(a) Water is used for domestic purposes aboard ship either as drinking water, culinary water, wash water, or sanitary water. The drinking water (including water used for washing the mouth and teeth) and the culinary water should at all times be free of disease-producing micro-organisms and should meet the standards of quality suggested in paragraphs 51 and 52.

(b) When conservation of fresh water or fuel is important, or when it is impracticable to provide fresh water of drinking quality for wash purposes (i.e., use in showers and laundries and for flushing decks, etc.) it may be necessary to use overboard water if it is not contaminated. (For suggested standards and tests see para. 52). Water in harbors, or off shore from native habitations and around fleet concentrations, should be assumed to be unfit for use in showers, laundries, and for flushing decks, and should not be used for such purposes unless the medical officer advises that it is safe to do so under the particular local circumstances. On naval vessels salt or overboard water is ordinarily taken from the fire and flushing system. On facilities that may use either salt or fresh water, the fresh water system should be physically disconnected before installing a connection to the salt water system and when fresh water is used the salt water supply should be discontinued, preferably by removal of a section of the salt water connecting pipe.

Use of overboard water in the galley is particularly hazardous and should be permitted only under careful supervision by the medical officer. The danger of cross-connections, the danger of using overboard water in polluted harbors and rivers, and the precautionary measures required to protect the health of the crew are discussed below in detail. Cross connections between the fresh and salt water or other systems which are liable to contaminate the potable water are not permitted.

(c) Overboard water from the fire and flushing system is used for general sanitary purposes such as flushing toilets, urinals, and garbage chutes. Within certain limits quality is not important. Some harbors are so contaminated with fecal matter, garbage, floating debris, and oil, however, that the water is unfit even for flushing purposes. Naval vessels should avoid foul water areas except on occasions when military necessity is involved. When ships are moored alongside one another, care should be taken to prevent discharging the sewage of one ship directly over the fire and flushing water or other sea water intake of an adjacent ship.

(d) A risky solution to the problem of foul overboard water is to connect the fire and flushing system to the shore water system. The fire system and the drinking water system ashore usually draw water from a common source even though separate outlets are provided. Therefore, connections between the fire and flushing system aboard and the water system ashore must never be permitted unless the shore system outlets are protected by check valves or other adequate backflow preventive devices. Not infrequently the fire and flushing system pump is started while a ship-to-shore cross-connection still exists and if no backflow preventer is provided harbor water is forced directly into the potable water system ashore.

3. Sources of Ship's Fresh Water.--Fresh water supplies for naval vessels are obtained by the following means:

(a) Distillation of outboard water.

(b) Filling of tanks through connections to a potable water system ashore.

(c) Transfer from a water ship (AW) or tanker used to bring water to forward areas. This water may have been purified before loading at a rear base or distilled aboard the water ship.

* BuShips Manual, Chapter 48 - PLUMBING

(d) The use of water barges to transport shore water to the ship.

(e) Direct loading of overboard water into the fresh water tanks. This practice is applicable only aboard ships operating in the Great Lakes or in other inland water of good quality. Such water should always be chlorinated before it is used.

4. Water Sanitation.

(a) Special sanitary precautions must be taken to protect the quality of water during its purification, loading, transportation. transfer, storage, and distribution. These measures will vary with each type of supply listed in paragraph 3. The mere fact that a water supply has been properly distilled or that it may have been purified earlier at some rear base does not assure its continued safety. The purification of water is a simple matter when compared with the difficulties involved in preventing its recontamination during handling, storage, and distribution.

(b) In order that water sanitation may be considered satisfactory, the following precautions should be taken:

(1) Keep the fresh water system entirely separate and disconnected from all other systems aboard ship.

(2) Wherever fresh water is used in any piece of equipment that may contain unsafe water, whether in galley, sick bay, the engine room, or elsewhere, admit water through a nonfloodable air gap.

(3) Clean and disinfect all tanks and parts of the fresh water system at least annually or whenever there is reason to suspect contamination.

(4) Do not use salt water for showers, laundry, flushing decks, etc., when in polluted areas. If alternate supplies are used in the same device, disconnect the salt water line before connecting the fresh water line.

(5) Disconnect all salt water lines leading into the galley, scullery, and food preparation spaces when the vessel is in an area where the overboard water may be contaminated. A closed valve provides no assurance against leakage or unauthorized use of contaminated water.

(6) Do not permit cross-connections between the fire and flushing system aboard and the potable water system ashore unless backflow preventers are used on the potable water outlets.

(7) When there are dual systems ashore ascertain that the fresh water tanks are filled from the potable water system ashore and not from the fire main.

(8) When water is taken aboard from the shore or from water barges or other ships, either test it bacteriologically and do not use until test results are available or chlorinate it as it comes aboard Guard against shore water that has been polluted through cross-connections established by other ships.

(9) When the ship is operating in polluted waters be assured that the distilling plant is functioning properly Do not send any distilled water of doubtful quality into the fresh water tanks.

(10) As an added factor of safety chlorinate all water stored in potable tanks when the ship is operating in polluted areas.

(11) Test the water in all fresh water tanks whenever its purity is in doubt or as frequently as necessary.

(c) It may be impossible to apply all the precautionary measures enumerated in paragraph 4 (b). If any one of them is not or cannot be put into practice, a certain amount of risk is accepted. This risk should be recognized, evaluated, and minimized by taking such precautions as are practicable under the circumstances.

(d) The danger of water contamination is greatest when the ship is in polluted harbors and least when at sea where the overboard water is pure. A ship that gets to sea with bacteriologically pure water in all tanks will rarely have any sickness aboard due to impure water. It should be remembered that it is always the bacteriological quality of drinking water that is important, and that in fresh water harbors, taste and salt tests lose most of their value as indicators of danger.

5. Quantities of Fresh Water Required.

(a) The normal minimum consumption of fresh water per man by the officers and crew of a naval vessel should be about 12 gallons per day. This amount includes water for drinking, galley and scullery use, ablution, and washing of clothing. While it is necessary to economize in the use of fresh water, the rules for Engineering Performances, United States Navy, do not contemplate an insufficient allowance of fresh water to meet all hygienic needs. Proper indoctrination of the crew and attention to leaks and waste should limit fresh water consumption to reasonable amounts. Arbitrary limitation of hours during which washrooms are open for use, or restriction of members of the crew to definite small quantities of water for bathing, tends to result in breaches of hygiene and may adversely affect morale. Water hours are necessary, however, on many ships,

particularly transports loaded beyond their capacity for living comfort and convenience, and it will be found that man may keep clean and live under sanitary conditions even with a limited water supply if proper supervision by division officers is maintained. If unusual conditions require drastic restrictions in the use of fresh water, the allowances should not be less than two gallons per man per day to be used only for drinking and cooking purposes.

(b) The use of salt water in showers and laundry when at sea will affect material savings in the quantities of fresh water consumed. Due to the danger of using polluted water for these purposes and the danger of cross-connections, however, judgment and careful supervision must be exercised when using salt water in showers, laundries, and other facilities. (See paragraphs 22 and 31.)

(c) The tables below give a general breakdown of the quantities of fresh water required aboard ship. Actual consumption will vary widely depending on the type of ship, and on the evaporator and tank capacity. When fresh water serves all uses the consumption rate may fall between 12 and 35 gallons per man per day, though the higher figure should be considered wasteful. When salt water is substituted for fresh water in showers and laundries, consumption should be less than 12 but rarely as low as four gallons per man per day.

CONSUMPTION OF FRESH WATER ABOARD SHIP

Type of use	Gallons per man per day
Drinking water	0.5 to 1.0
Galley and scullery	1.5 to 4.0
Ablution	5.0 to 20.0
Laundry	5.0 to 10.0
Total	12.0 to 35.0

CONSUMPTION OF FRESH WATER WHEN SALT WATER IS USED IN SHOWERS, LAUNDRIES, ETC.

Type of use	Gallons per man per day
Drinking water	0.5 to 1.0
Galley and scullery	1.5 to 3.0
Ablution	1.0 to 5.0
Laundry	1.0 to 3.0
Total	4.0 to 12.0

6. Emergency Supplies.

(a) The forward and after battle-dressing stations should each be equipped with a fresh water tank of capacity as follows:

200 gallons for vessels with total and troop complement over 500; 100 gallons for vessels with total ship and troop complement less than 500 except on destroyers and vessels of a similar type which shall be provided with tanks of 50-gallon capacity. On a ship having an amidship battle-dressing station, this station should be equipped with a tank of 100-gallon capacity. Prior to action, buckets and tubs, if convenient, should be filled and placed at the battle-dressing stations for use if the connections with gravity tanks should be damaged or destroyed.

(b) Emergency drinking water supplies should be made available in turrets and at other battle stations to provide for the crew if the fresh water system is damaged during action. Life rafts and other life-saving facilities that are normally provisioned must at all times carry supplies of potable water.

(c) Emergency supplies must be checked occasionally to assure that the tanks are filled and that the water is fit to drink. When the vessel is operating in an active area such inspections should be made at least weekly.

7. Responsibility for Water Supply.

(a) It is the medical officer's responsibility to make certain that the water is potable at all times. He should work closely with other ship's officers having cognizance over matters pertaining to water supply and should, with these officers, acquire a thorough knowledge of all details relative to the sanitary handling and storage of water, the prevention of hazardous cross-connections both aboard ship and between the ship and shore, and the precautions that must be taken when the vessel operates in polluted water. The medical officer or a competent representative of the medical department should inspect connections when fresh water is loaded, and, after loading, should test the water bacteriologically or submit samples to a convenient hospital or laboratory for analysis. The complaints of crew members that the taste of the water is bad is often the first indication of a serious lapse in water sanitation. Such complaints should be reported immediately to the medical officer, who should determine the cause of the trouble.

Figures 6-1 to 6-6 are examples of plumbing fittings which may cause contamination of the fresh water supply.

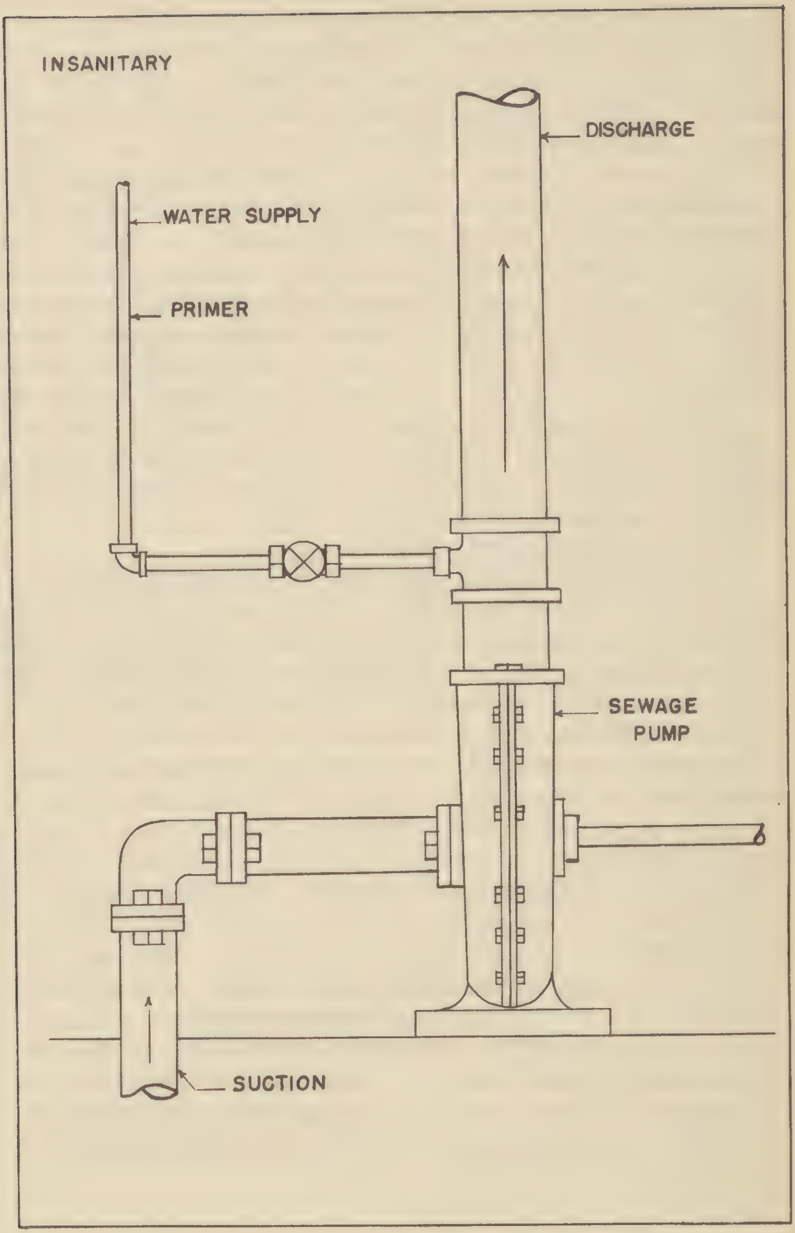

Figure 6-1.--A cross-connection of a sewage pump

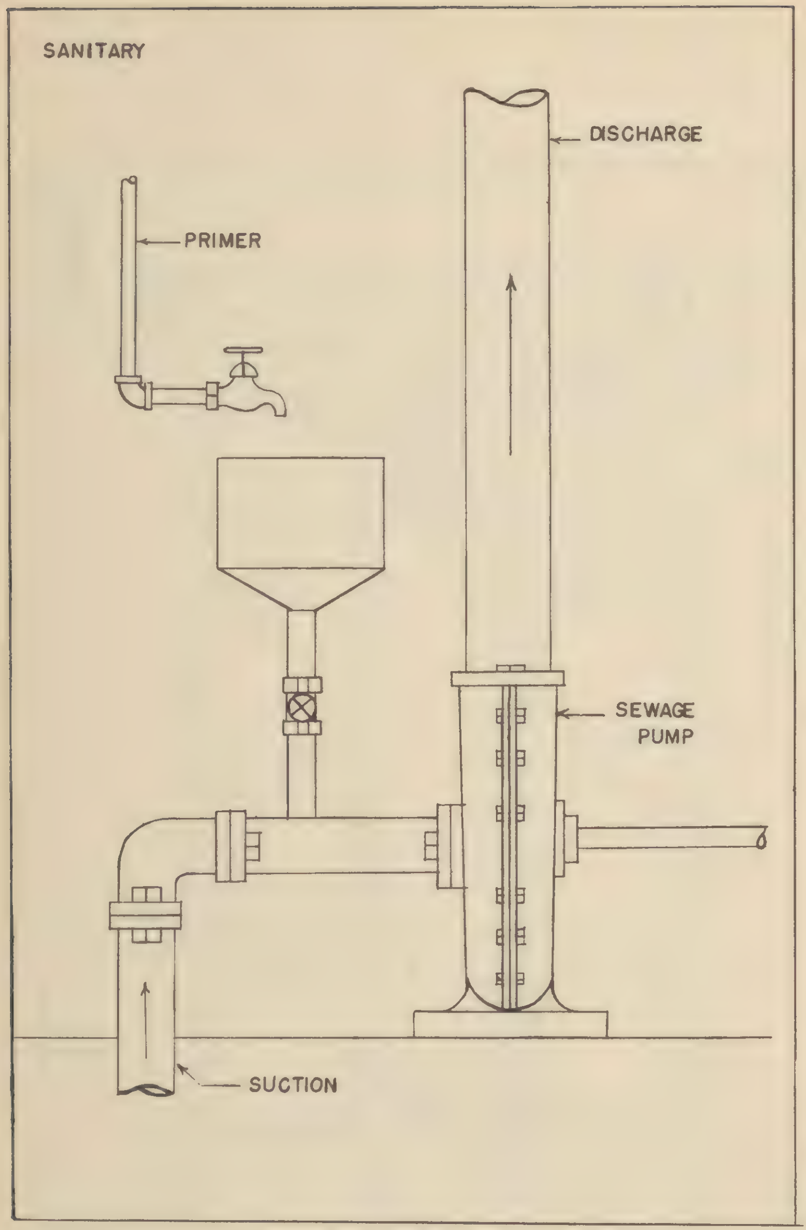

Figure 6-2.--A correction of the cross-connection as shown in figure 6-1

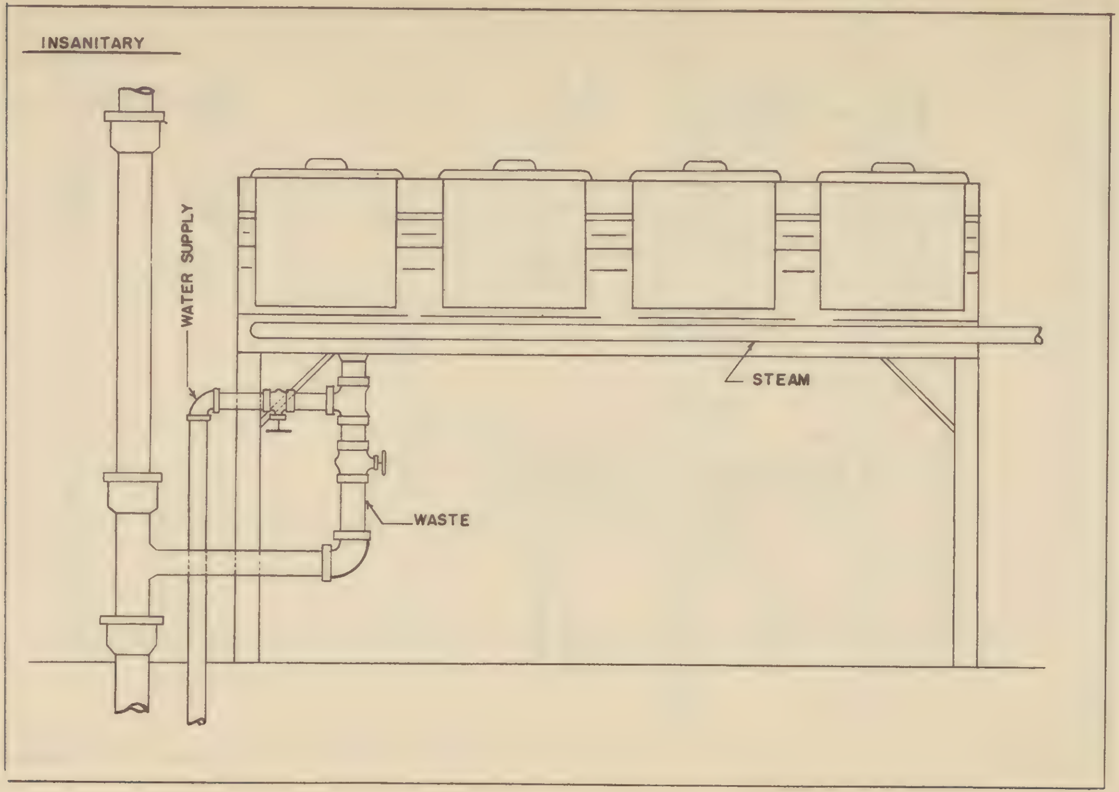

Figure 6-3.--A cross-connection of steam table plumbing

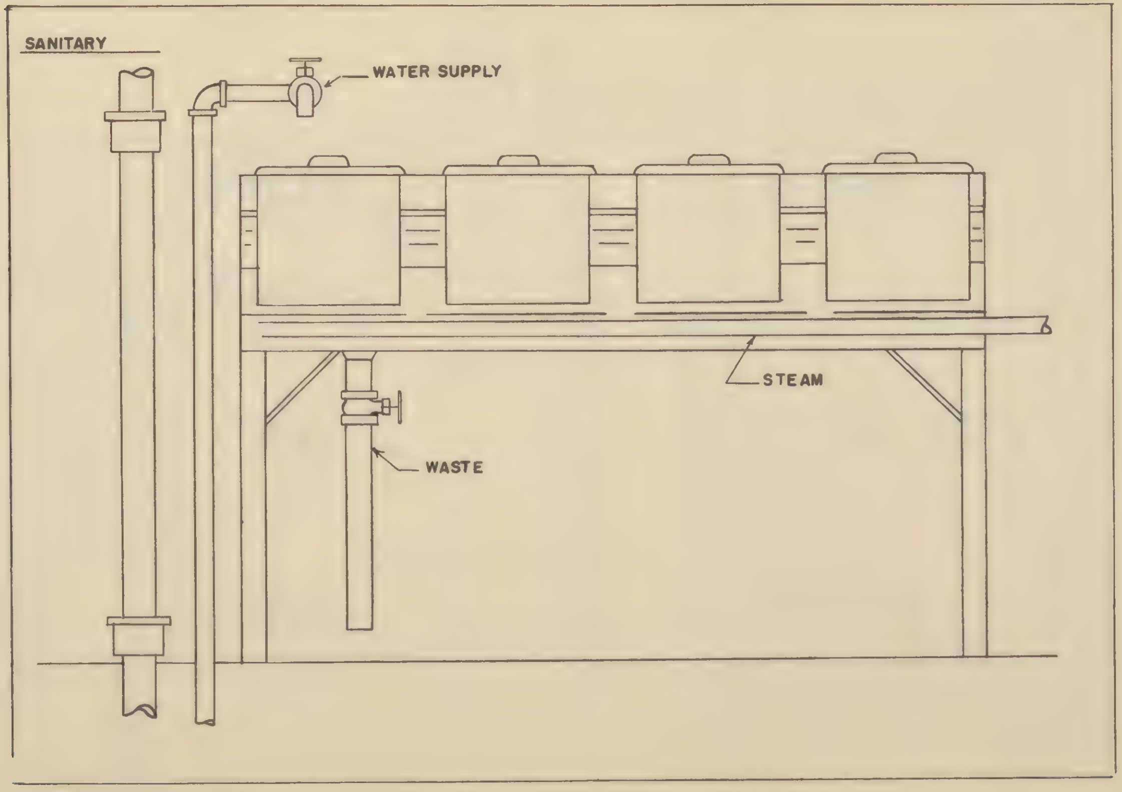

Figure 6-4.--A correction of the cross-connection as shown in figure 6-3

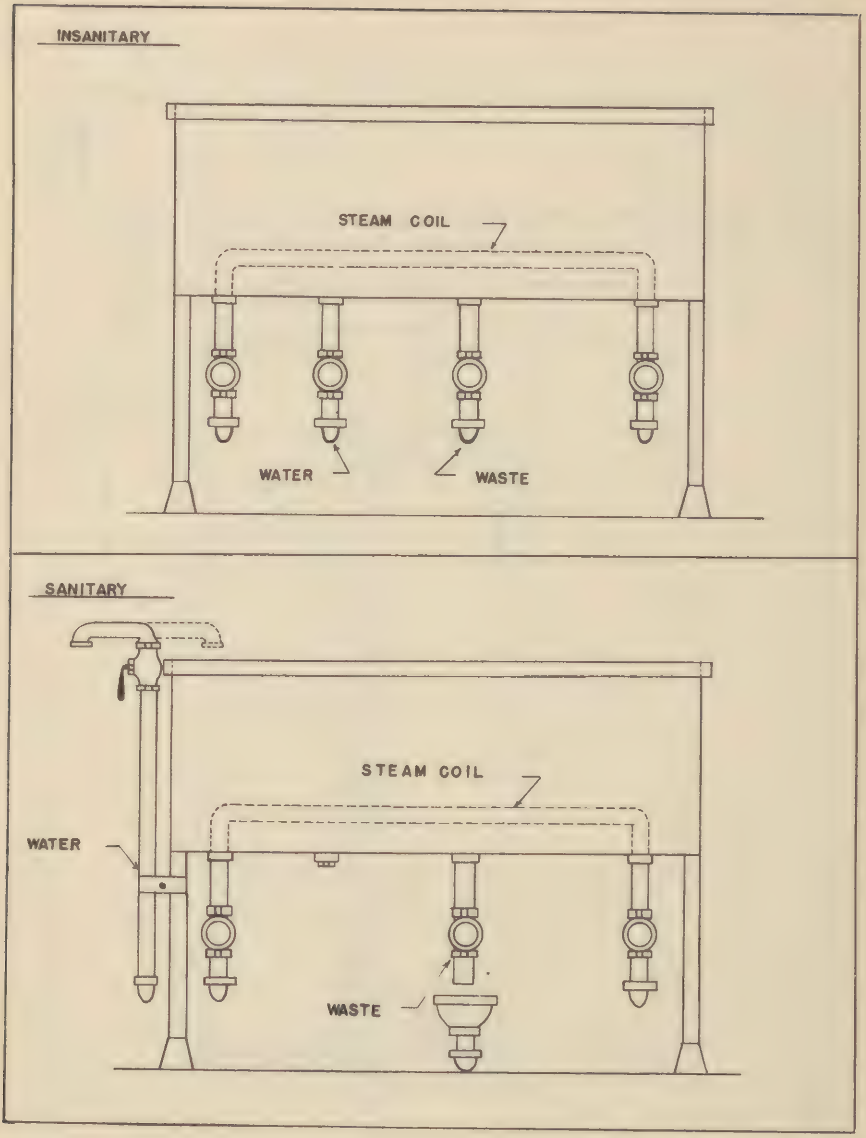

Figure 6-5.--A steam table hook-up changed from insanitary to sanitary

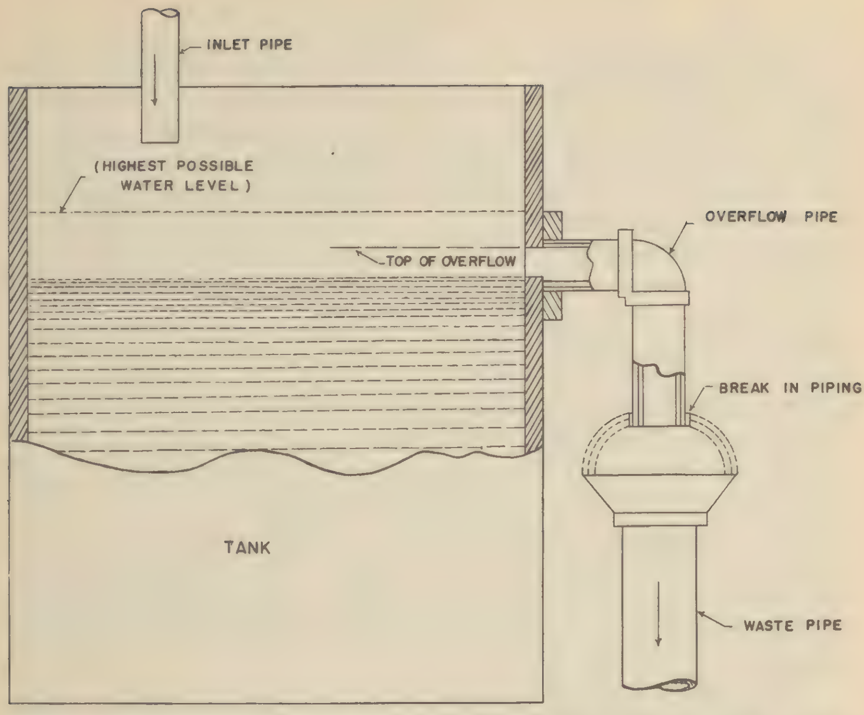

Figure 6-6.--A sterilizer in which the plumbing has been corrected from an insanitary to a sanitary installation

(b) The sick bay is often considered a place where extravagant use of fresh water prevails. The medical department should observe the following "don'ts":

(1) Don't allow the use of water suction for drying test tubes and pipettes in the laboratory.

(2) Don't permit the use of a constant flow of fresh water through X-ray developing tanks. Use ice for cooling if necessary.

(3) Don't permit the use of a large stream of water over scrub-up basins. Have small needle shower heads installed on the outlets and be assured that the knee-action valves function smoothly. If necessary, scrub in a basin and have small amounts of clean rinse water poured over the hands by an assistant.

(4) Don't allow dripping faucets. Report leaks to the first lieutenant and see that they are repaired promptly.

8. Storage Tanks.--It would be desirable from the sanitary viewpoint to store all fresh water in detached tanks. In order to fully utilize the hull spaces of many fighting ships, however, fresh water is stored in the inner bottoms and other shell tanks. The ship's bottom, which serves as the outer shell of inner bottom tanks, is subjected to maximum external pressure from water that may be heavily polluted and is also vulnerable to leakage through damage from underwater explosions or grounding. The plating over the inner bottom serves as the machinery space deck. Furthermore, inner bottom and other shell tanks may nave common bulkheads with ballast tanks and oil and other storage spaces. These potential sources of impurities make it necessary to devote careful attention to maintaining the quality of water stored in inner bottoms or skin tanks when the vessel is in polluted harbors.

9. Manholes.--Manhole covers should be watertight and should be kept locked or bolted in place. The tanks should be entered only when absolutely necessary. Tanks which have been entered should be decontaminated in accordance with procedures described in Section IV.

10. Depth Water Gages.--Gaging the depth in potable water storage tanks by insertion of sounding rods or lines into tubes or manholes is considered an insanitary practice that should be resorted to only in emergencies.

11. Filling Lines.--In no case should filling lines be cross-connected with any other pipe system. Inlets should be clearly labeled and, when not in use, covered with screw caps. Hose lines for taking aboard fresh water should not be used for any other purpose. If provided by the ship they should be kept in special lockers that are conveniently located and adequately labeled to prevent use of either the hose or the locker for other than its intended purpose. Inside the doors of such lockers there should be posted instructions and precautions relative to loading of fresh water.

12. Tank Linings.--In order to avoid difficulties with taste and the danger of toxic chemicals, only those tank lining materials specified by the Bureau of Ships as satisfactory for potable water tanks should be used. After a new coating of lining material has hardened, tanks should be cleaned, flushed, and decontaminated in accordance with procedures described in Section IV.

13. The Fresh Water System.--The fresh water distribution system delivers potable water to galleys, sculleries, and pantries; to the hospital, sick bay, and other medical facilities; to laundries, scrub decks, showers, and washrooms; and to drinking water coolers distributed throughout the ship. The fresh water distribution system must be independent of all other systems, free of cross-connections, and protected against contamination from back-siphonage, backflow, or leakage into any part of the system.

14. Cross-Connections.--A cross-connection is any physical connection or arrangement of pipes between two otherwise separate water supply systems whereby water may flow or leak in either direction between the systems. Valves and blind flanges are not dependable as means of separating the potable water distribution system from other systems. Potable water should be delivered or discharged through nonfloodable air gaps to all pipes, tanks, or water-using facilities that may at any time contain water of inferior quality. Facilities which must be provided air-gap protection on fresh water inlets include boiler feed tanks, engine-cooling systems, galley and pantry sinks, dishwashers and other scullery equipment, vegetable peelers, laundry machines, lavatories, and hospital sterilizers and fixtures of all types. All drainage outlets in the fresh water system, whether to sewers, drains, or the bilge, should be protected from flooding by the use of air gaps. Locations of the fresh water inlets above the rims of lavatories, sinks, and other open receiving vessels constitutes an adequate air gap. Delivery of potable water to closed containers or systems or its discharge to drains and sewers should be through a free opening located above the rim of a receiving funnel. (See figs. 6-1 to 6-5.)

15. Water Pumps.--All fresh water pumps should be airtight and should have airtight suction lines free of cross-connections. Packing gland seals should be maintained by using water identical in quality to that handled by the pump. Water inferior in quality to that pumped should never be used for priming pumps. If higher quality water is used for priming purposes it must be admitted to the pump casing through an air gap. (See fig. 6-1.) Pumps that have been dismantled for repair should be decontaminated after reassembly and before they are put into service.

16. Posting and Labeling Water Systems.

(a) All faucets, hydrants, and other outlets on any system not carrying potable water should be clearly posted "Unfit to

Drink.'' Hydrants or other connections used for loading fresh water should be labeled. Hydrants on the fire and flushing system should be stenciled to prevent confusion in emergency and also to forestall cross-connection of the fire and flushing system with the potable water system ashore.

(b) In order to trace and identify the various water and other pipe systems and to warn against imporper connections, all pipes are stenciled with the name of the fluid carried or are painted or banded with distinguishing colors. Each line has at least one designation in each compartment through which it passes.

(c) The ''Scheme for Identification of Piping Systems'' recommended by the American Standards Association and sponsored by the National Safety Council and the American Society of Mechanical Engineers will probably be found in use on merchant vessels. Since Medical Department personnel may serve aboard such vessels, the system is presented:

PIPE IDENTIFICATION

Quality of water	Color
Potable or drinking water	Light blue.
Wash water	Yellow.
Sanitary water	Orange.
Fire service	Red.

Section IV.--DECONTAMINATION (DISINFECTION) OF FRESH WATER TANKS AND SYSTEMS

17. When Decontamination Is Required.

(a) The various parts of the potable water system, such as tanks, piping, fittings, fixtures, scuttlebutts, pressure tanks, pumps, etc., should be decontaminated (disinfected or sterilized) on the following occasions:

(1) Prior to the delivery of a new ship.

(2) Following routine cleaning and refinishing of the interior of tanks or other parts of the system.

(3) When the system or any of its parts have been dismantled or replaced for purposes of repair or alteration.

(4) Before tanks that have been used for storage of contaminated ballast water or other impure water are put into use for storage of potable water.

(5) At any time contamination of the tanks or of the system is suspected because of known leaks or known mistakes in water sanitation, or whenever contamination is

indicated by bacteriological or chemical tests or by an outbreak of water-borne disease.

(b) Judgment must be used in deciding when decontamination procedures shall be applied and how much of the system requires treatment. If the contamination is not heavy and is transitory it may be advisable in the interests of water economy to give protection by chlorinating the water until the danger has passed or until the ship is returned to a yard where the system can be completely overhauled and thoroughly decontaminated.

18. Cleaning and Flushing of Tanks and Systems.

(a) Tanks must be scrubbed clean and flushed before decontamination is started. Flushing must be continued until all possible foreign matter has been completely removed from the tank. Personnel assigned to work in fresh water tanks should (1) be free of infectious disease; (2) bathe before entering; (3) wear freshly laundered clothing; (4) put on clean boots immediately prior to entering; and (5) follow the rules of sanitary conduct. The usual precautionary measures against asphyxiation should be taken before entering water tanks.

(b) After the tanks have been cleaned, all other parts of the fresh water system must be thoroughly flushed to remove rust, scale, or other foreign matter. The exact procedure to be used must be adapted to local circumstances. Flushing should be so conducted that pipes and all other parts of the system are washed out with water flowing at a velocity of not less than six feet per second. Injection of compressed air improves the flushing action of water. In some instances it may be necessary to disconnect lines in order to obtain adequate flushing velocities. Flushing should be so planned that foreign matter is washed completely out of the system, not merely carried from one place to another. Any material flushed into the tanks must be removed.

19. Decontamination.

(a) Chlorine gas or chlorine compounds are universally used for decontamination of water tanks and systems. The most suitable compounds are Grade A hypochlorite (HTH, Perchloron, etc), calcium hypochlorite (chlorinated lime), or commercial sodium hypochlorite solutions (Chlorox, Zonite, etc.). Since these compounds deteriorate, they are purchased in small containers which should be kept closed and stored in a cool, well-ventilated space. Chlorine compounds that have been on hand for six months or more should be checked for strength.

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(b) In decontaminating a system, all tanks and all parts must be filled with heavily chlorinated water which is maintained in contact with interior surfaces for a period sufficient to kill all micro-organisms. Several standards relative to chlorine concentration and contact time have been used. Three which are considered acceptable are listed below in order of preference:

(1) Treatment to maintain a free chlorine residual of at least 40 to 50 ppm for four hours.

(2) Treatment to maintain a free chlorine residual of at least 80 to 100 ppm for one hour.

(3) Use of an initial dose of 50 ppm with the requirement that after 12 hours' contact the water shall contain at least 5 ppm free chlorine.

20. Continuous Chlorine Feed Method of Decontamination. When equipment is available for continuous feeding of either chlorine gas or chlorine solutions, the fresh water used for decontamination can be superchlorinated as it runs into the tanks and system. The feed machine should be set to give a dose that will maintain the residual specified at the end of the contact period. When filling the system, water should be bled from all outlets until the heavily chlorinated water appears. The fresh water tanks are then filled to overflowing, and if possible the superchlorinated water is circulated through the tanks and lines for the period required. If recirculation is used, the chlorinator may be set to introduce enough chlorine to build up or maintain the required chlorine concentration.

21. Batch Chlorination Method of Decontamination.

(a) In the absence of a mechanical chlorinator, the batch method of decontamination using Grade A hypochlorite or other chlorine compound must be employed. It is necessary to determine the volume of water required completely to fill each tank and the system and the amount of chlorine compound required for each, allowing for loss of chlorine during the contact period.

Make up the chlorine solution by first mixing the hypochlorite powder with one gallon of water per pound of chemical. This preliminary solution is then diluted with sufficient water to permit easy pouring into a tank. Add the chlorine solution to the tank when it is one-fourth full and immediately fill to overflowing. Sufficient mixing usually will be obtained by the swirling action of the incoming water. Circulation of the water through a pump and back to the tank will assure thorough mixing and proper contact with the tank walls.

For disinfecting tanks and pipes the following tables may be used as a reasonably accurate guide for chlorination and dechlorination by the batch method. Cubic feet may be converted into gallons by multiplying by $7\frac{1}{2}$.

Tank capacity (gallons)	Amount of sterilizing agent in grams: Chloride of lime	H. T. H. or perchloron	Sodium thiosulphate
500	21	.7	.7
1,000	42	18	14
1,500	63	21	21
2,000	84	28	28
2,500	105	35	35
3,000	126	42	42
4,000	168	56	56
5,000	210	70	70
10,000	420	140	140
15,000	672	210	210
20,000	840	280	280
25,000	1,008	350	350
50,000	2,016	700	700

A heaping teaspoon holds approximately 14 grams and a standard measuring cup approximately 168 grams. These measuring devices will serve the purpose. However, a large excess is to be avoided.

Quantities of H-T-H[1] to sterilize water pipe lines

Pipe diameter in inches	Contents gallons per 100 feet	Ounces of H. T. H.[1] required per 100 feet
1	4.08	0.1
2	16.32	.2
3	36.72	.4
4	65.28	.7
6	146.9	1.5
8	261.1	3.0
10	408.0	4.0
12	587.5	6.0
16	1,044.0	11.0
20	1,632.0	17.0
24	2,350.0	24.0

[1]High-test hypochlorite.

To obtain a chlorine residual of 50 parts per million requires 700 pounds H-T-H per million gallons or 10 ounces per thousand gallons.

(b) The field method or "drop dilution" method is sufficiently accurate for determining concentrations of chlorine residuals for disinfecting water mains and storage tanks. Materials and apparatus required to perform the test include:

(1) Distilled water.

(2) Medicine dropper or pipette of such size as to deliver approximately 20 drops per ml.

(3) A comparator with permanent chlorine disc stand ards, and two 15 ml: sample cells (test tubes)

(4) Standard ortho-tolidine test solution in amber colored drop bottle with a dropper that will deliver 0.5 ml.

(5)

(c) Procedure for determining concentrations of chlorine residual:

(1) Collect sample to be tested in small container.

(2) Add 0.5 ml. ortho-tolidine to center tube and fill to the mark with distilled water.

(3) Fill the other tube with distilled water. (Do not use water under test as in usual procedure because dilution will make it unnecessary to compensate for turbidity.)

(4) Add one drop of water being tested to distilled water in the center tube, mix and read immediately. If no color appears add additional drops, one at a time until a reading within the range of the color disc is obtained.

(d) Computation of Residual

(1) Divide 15 (number ml. distilled water in center tube) by the number of ml. of sample added to show color. Each drop equals 0.05 ml. if the dropper delivers approximately 20 drops per ml.

(2) Multiply the reading obtained by the dilution factor as found in (1).

Example: 1 drop of sample added to the center tube shows a residual of 0.2 ppm. The dilution factor is 300 (15 divided by 0.05) and the computed residual is therefore 0.2 ppm x 300 or 60 ppm.

(e) When all the tanks to be decontaminated are filled with superchlorinated water, open the taps and outlets nearest the tank which supplies the distribution system and permit them to flow until the chlorinated water appears. Continue this process outward from the tank until all outlets have been

flushed with superchlorinated water. Care should be taken to see that the pressure tank and all pumping and other equipment in the potable water system are filled with chlorinated water. The tank or tanks from which water has been drawn to decontaminate the system must then be refilled to overflowing after putting in more chlorine solution. After the required contact period the tanks and system are refilled with potable water and are ready for use.

AMOUNTS OF CHLORINE COMPOUND TO TREAT 1,000 GALLONS OF WATER WITH 100 PARTS PER MILLION (BY WEIGHT) CHLORINE*

Type of compound	Amount required
Grade A hypochlorite (HTH, perchlorite, etc.)	1.2 lb.
Calcium hypochlorite (chlorinated lime)	3.2 lb.
Sodium hypochlorite (5% sol.)	2 gal.
Sodium hypochlorite (10% sol.)	1 gal.
Liquid chlorine	0.83 lb.

*Other doses for various quantities of water can be readily figured by applying proper ratios.

(f) Both water and chlorine may be conserved by decontaminating one tank at a time. By this method the superchlorinated water may be used in each successive tank with addition of sufficient chlorine compound to bring the concentration up to the required strength.

Section V.--ALTERNATE USE OF FRESH AND SALT WATER

22. The danger of using salt water when in polluted harbors and the importance of preventing dual connections and cross-connections when fresh and salt water are used alternately have already been mentioned. The various installations in which alternate use is permissible present problems which differ in type and degree of hazard and in precautionary measures required. The purposes for which either salt or fresh water may sometimes be used are: (a) Showers; (b) Laundries; (c) Galley, scullery, and food preparation spaces; (d) Vegetable peelers; (e) Cooling jackets or other engine room equipment; (f) Flushing decks; (g) Fresh water in salt water systems for marine life extermination; and (h), Salt water in fresh water tanks for ballast purposes.

23. Prevention of Cross-Connections.--At every point where salt or fresh water may be used alternately the rule stated in paragraph 2 (b) should be followed: When salt water is used, the fresh water system should be disconnected by removing the hose used to admit fresh water or by removing a section of the fresh water pipe; when fresh water is used, the salt water supply should be secured--preferably be removal of a section of the salt water connecting pipe. If the salt water is not physically disconnected when fresh water is in use then the fresh water must be admitted through a nonfloodable air gap. Otherwise a direct cross-connection will be established.

24. Showers.--The use of salt water in showers is considered necessary for conservation of fresh water at sea. Under no conditions should both salt and fresh water be connected to the same shower head. Salt water showers should not be used when the overboard water at the salt water intake is of such quality that the medical officer would not permit swimming in the vicinity of the intake. In terms of bacteriological quality the water around the intake should have a coliform density of less than 100 per ml. and preferably less than 50 per 100 ml. (See paragraph 52.) Furthermore, conditions of operations should be such that there is no chance of sewage discharges from the same or other ships being drawn into the salt water intake. Shower heaters, if used for salt water, should not supply hot water for any facilities other than the showers.

25. Laundries.--Important conservation of fresh water results from the use of salt water in laundries. The water must be relatively clear and free of marine growths and other substances that might cause staining. If clothes are bleached or ironed, any water that is clear enough to give a satisfactory wash will probably be safe to use in the laundry.

26. Galley, Scullery, and Food Preparation Spaces.

(a) Serious risks are taken when salt water is used in the galley, scullery, and food preparation spaces. It is considered imperative that all uses of salt water in such places be prevented by foolproof measures whenever the water drawn from the overboard system is contaminated. It is suggested that the medical officer or medical department representative recommend the following measures to reduce the dangers inherent in using salt water to wash vegetables, dishes, utensils, and equipment:

(1) Make it the responsibility of the medical officer or other medical department representative to see that all

salt water lines entering the galley, scullery, and food handling spaces are physically disconnected before the vessel enters an area where the overboard water may be contaminated.

(2) Permit the reconnection of these lines only after the medical officer or other medical department representative has advised that it is safe to do so.

(b) In deciding when it may be reasonably safe to reintroduce overboard water into the galley, scullery, and food preparation spaces the following factors should be kept in mind:

(1) An overboard water system that has been fouled in a contaminated harbor may continue to discharge impure water after the vessel is at sea.

(2) The possibility of drawing contaminated water into the intake of a lone vessel under way in the open sea is extremely remote. As the number of vessels in an area increases, however, or as their motion relative to the water decreases, the chances of drawing contaminated overboard water become greater and approach by degrees the condition that prevails in a congested harbor.

(3) It has been assumed that the water around vessels operating in formation or in convoy is not contaminated sufficiently to be of concern, but this is not known. The water around a large aggregation of ships receives the fresh fecal discharge from a population as large as that of a medium sized city.

(4) Evidence of food contamination from sea water as a cause of infection is such as to force abandonment of the use of sea water in commissary spaces and in equipment, including vegetable peelers, within 10 miles of entrance to and in ports and anchorages. Where contaminated waters are known to extend more than 10 miles, necessary increased distance will be observed.*

(c) Bacteriological tests are the only tests of value for determining the quality of water drawn from the overboard system. But the quality of overboard water around a vessel moving in and out of harbors may change so rapidly that bacteriological tests are not likely to produce results of immediate value. Well

* BuShips Manual, Chapter 48 - PLUMBING

planned programs for testing samples of overboard water, however, should provide data to guide the medical officer in forming an opinion as to the places and circumstances in which it is not safe to use overboard water in the galley. Simple bacteriological tests are described in paragraph 52.

27. Vegetable Peelers.--Vegetable peelers present a difficult sanitary problem for two reasons: (a) Vegetables peeled in them may be served raw; and (b) the machines consume relatively large quantities of water. When fresh water must be assiduously conserved, there seems to be a strong tendency to continue the use of overboard water in the vegetable peeler without much concern as to its quality. The practice of using potentially contaminated water to peel vegetables should be stopped, even if such action requires breaking out the paring knives. Disconnection of the salt water line to vegetable peelers is strongly recommended when water from the overboard system is contaminated.

28. Cooling Jackets, etc.--When it is necessary to admit fresh water to engine cooling circuits or other systems which normally carry nonpotable water, the air-gap principle should be used to protect the fresh water.

29. Flushing Decks.--Good sanitary practice prohibits the use of potentially contaminated harbor water either upon or below the upper decks of naval vessels.

30. Use of Fresh Water for Extermination of Marine Growths.--The periodical use of fresh water in all salt water systems for the purpose of killing marine growths presents a variety of problems. Normally the job is done when the vessel is docked and fresh water is available ashore. In fact this is one of the causes of troublesome ship-to-shore cross-connections. If the ship's fresh water is used for destroying marine growth, it should be admitted through an air gap on the suction side of the salt water pump. If this is impracticable because of a need for maintaining automatic flow or continuous pressure from the fresh water system, then all overboard or other normal salt water intakes that feed the circuit under treatment should be disconnected by removing a section of pipe. Superchlorination of a salt water system is another method of killing marine growths Since fresh water need not be used, the method is entirely safe from the point of view of sanitation.

31. Use of Fresh Water Tanks for Salt Water Ballast.--Fresh water tanks should not be used to carry salt water ballast unless there is no other way to assure stability of the vessel.

If possible the ballast should be loaded when the vessel is at sea. Fresh water tanks and lines that have been filled with overboard water must be decontaminated before they are again used for potable water. If the ballast water is loaded at sea, decontamination may be accomplished by superchlorinating the ballast water. If the ballast is loaded in or near harbors or fleet concentrations, however, the ballast must be dumped and fresh water used to flush and decontaminate the tanks and system. (See paragraphs 17 to 21.)

Section VI.--SUPPLIES FROM SHORE

32. Quality of Shore Water.

(a) Before cooking and drinking water from shore is taken aboard, the medical officer shall investigate its source, make as complete an examination of it as possible with the means available, and report at once if any doubt exists as to its purity. All such examinations shall be entered in the journal.

(b) Most municipal water supplies in the United States and its territories and all shore supplies operated by the Navy are purified. With but few exceptions water from these shore supplies will be potable if protected against contamination from cross-connections between the shore system and the fire and flushing systems of vessels. All water supplied by public or private systems outside the United States should be considered of doubtful quality.

(c) Improper loading technic sometimes accounts for water contamination. Barging water to the ship multiplies the opportunities for contamination; not only does danger exist during loading of the barge and transfer to the ship, but the storage and pumping practices on some water barges are highly insanitary. In order to safeguard water taken from barges, it is advisable to chlorinate it and to determine its quality after it has been loaded.

33. Ship-to-Shore Cross-Connections.

(a) Many instances have been reported in which the fire and flushing systems aboard ships have been connected to the potable water systems ashore without the use of backflow preventive devices. Subsequent operation of the ship's fire and flushing pumps has resulted in the pumping of polluted harbor water into the drinking water system ashore. If the harbor water is salty the presence of impure water will be discovered before serious damage is done. On the other hand, when this accident occurs in a fresh water harbor a severe epidemic may be under way before pollution is detected. If a municipal

water system within the continental United States is involved, the establishment of cross-connections with a source of inferior water constitutes a violation of a state law or a municipal or water department ordinance or regulation.

(b) All connections between the fire and flushing system (or other system not providing water of drinking quality) aboard ships or boats belonging to the Navy and potable water supply systems ashore are forbidden unless an adequate backflow preventer is installed in the line between the naval vessel and the potable water supply ashore.† In salt water harbors a single check valve may be used although protection by dual check valves or better is desirable. Ultimately, all potable water outlets on naval docks will be equipped with check valves or other backflow preventers, but this practice probably will never be followed at all docks where naval vessels load water. The proper dock authority should be consulted to learn whether or not backflow preventers are used on each potable water outlet. If they are not, all ship-to-shore cross-connects must be prevented. Moreover, the shore water should be viewed with suspicion for it may easily be contaminated by other ships docked in the area.

(c) The above precautions apply when the water system ashore supplies the potable and fire systems from the same source. Occasionally docks are provided dual systems similar to those aboard ship. Under such conditions the fire system ashore is operated by pumps which draw water from the harbor. Connections between the fire and flushing system aboard and such harbor water fire systems ashore need not have backflow preventers. When there are dual systems ashore as well as aboard, however, care must be taken to assure that (1) the fire and flushing system aboard is connected only to the fire system ashore, and (2) the fresh water system aboard is connected only to the potable water system ashore. Competent representatives of both the dock and the vessel should check connections at the time they are made. The medical officer should keep in mind the fact that control of the ship's connections does not protect it from mistakes made by other vessels.

34. Loading Shore Water.--When potable water is taken aboard from shore sources the procedure should conform, as nearly as may be practicable, to the following instructions:

(a) The responsible officer of the vessel should determine by inquiry of a competent authority whether or not there is available at the particular dock a safe potable water supply. At docks other than those owned or operated by the Navy the

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†See reference, p. --.

supply should have the approval of a state department of health or the United States Public Health Service.

(b) The responsible officer of the vessel should determine by inquiry of a competent dock official the location of hydrants which deliver water from the approved source whenever dual systems exist and the hydrants are not distinctively marked. This information should be transmitted with instructions to the men who will make connections and operate the hydrants.

(c) The fresh water hose should be broken out of its special locker and laid from dock hydrant to ship hydrant. The hose should be carried so that ends will not drag and no part of the hose will fall into harbor water. Upon attachment to the dock hydrant, the hose should be flushed vigorously for at least 30 seconds or until the water runs perfectly clear.

(d) At this stage it is advantageous to taste the water and, if it is supposed to contain chlorine, to test it for the chlorine residual. Gross contamination might thus be discovered before water is admitted to the tanks.

(e) The fresh water hydrant connection aboard ship should be made and after the layout has been inspected and approved by the responsible officer, the fresh water tank or tanks may then be filled. If the water is chlorinated as it comes aboard, the chlorinator should be rigged and set in operation before the hydrants are opened.

(f) When the loading is complete the fresh water hose should be disconnected and drained, all caps and plugs replaced, the hose washed if necessary, and then stowed in its locker with the same care used in breaking it out.

(g) Finally, water samples should be taken from each tank for bacteriological analysis. If these analyses show the water to be safe, it may then be admitted to the fresh water system. A day or more is required for making bacteriological tests. If the delay involved would cause an unreasonable hardship, the water may be assumed to be safe if, as it comes aboard, it is chlorinated sufficiently to give a free chlorine residual in samples from the potable water tanks of not less than 0.2 ppm 20 minutes or more after the tanks are filled.

35. Taking Water from Barges and Ships.--The same precautions must be observed in transferring water from water barges and ships as are used when shore water is loaded at a dock. Many Navy water barges, water ships, and other auxiliaries which supply water to the fleet carry chlorinating equipment and, in come cases, facilities for bacteriological analysis of water. When the auxiliary chlorinates the water the ship is relieved of this job. Samples should be taken for analysis,

however, after the ship's potable water tanks are filled. If water barges and water ships are not designed and operated in accordance with all the sanitary principles discussed in this chapter, the water received from them must be considered of doubtful quality unless properly chlorinated.

Section VII.--DISTILLED WATER

36. Types of Distilling Plants.

(a) Distilling plants are of four general types: low pressure, high pressure, vapor compression, and exhaust gas heated. The primary parts are the evaporating units and the distilling condenser. In addition to these there are a variety of heat exchangers, pumps, regulating mechanisms, etc. Steam-operated stills ordinarily are multiple effect; that is, they comprise a series of compartments in which evaporation occurs. The first is steam heated, the second is heated by and acts as a condenser for vapor from the first, the third is heated by and is the condenser for the second, and so on. The distilling condenser condenses vapor from the last effect and serves as the first of a series of feed water heaters which extract heat from the vapor passing from one effect to the next. Both the temperature and the pressure must decrease in succeeding effects.

(b) The low pressure type still is designed to operate on auxiliary exhaust steam at a pressure of 1 to 5 pounds per square inch and is usually arranged to operate in multiple effect with the last effect under a pressure of about four inches mercury absolute pressure (12.7 lbs/sq. in vacuum). Double or triple effect plants are usually provided.

(c) The high pressure type uses high pressure steam taken through a reducing valve and operates with the last effect pressure slightly above atmospheric. Piping connections for operation on steam drawn from the auxiliary exhaust are now generally installed and used, thus converting these plants into the low pressure type.

(d) Vapor compression distilling units for shipboard use consists of an evaporator, heat exchanger, motor-driven vapor compressor, and various pumps and control equipment. After the plant has been started by the use of electric heaters, the vapor compressor is used to heat the steam by compression. The compressed steam is returned to the steam chest of the evaporator, where it condenses and furnishes the necessary heat to continue the boiling of the sea water.

(e) The exhaust gas heated type is used in submarines and other Diesel-powered vessels. The exhaust gas from the engine boils the water in the evaporator heating tubes located directly in the exhaust line. The units are single effect.

37. Care of Distilled Water.

(a) The distillation plants aboard naval vessels supply water to the fresh water system and the boiler feed water system. The Manual of Instructions of the Bureau of Ships contains detailed instructions concerning the care of boiler feed water and make-up water. Information which is pertinent to the care of potable water is reproduced below for the information of the medical officer. Salt contamination of boiler feed water is always of serious consequence regardless of where the ship is operating. As far as taste is concerned, salt in amounts less than 20 grains per gallon is not noticeable. If the overboard water is polluted with sewage, however, salt contamination indicates possible fecal contamination of the potable water and the presence of more than a fraction of a grain per gallon of salt in the potable water is less permissible even than salt in the boiler feed water.

(b) The following paragraphs are quoted from the Bureau of Ships Manual:

The most prolific source of contamination of the water in naval boilers is the salt water leakage into the fresh water system. The principal parts of the system where this leakage may occur are listed below:

(1)* Condensers: Main, auxiliary, dynamo, augmentor.
(2) Salt water cooled air ejector condensers.
(3) Evaporators.
(4) Distilling condensers.
(5) Evaporator feed water heaters, condensate coolers, and drain coolers.
(6)* Salt water cooled gland exhaust condensers.
(7)* Leaky bottom-blow valves on idle boilers.
(8) Leaky feed suction and drain lines which run through bilges.
(9) Leaky seams and rivets in reserve feed tanks.

Condensers are the most common source of salt water leakage into the fresh water system. Particular attention should be given to establishing a routine to detect leakage of salt water into the fresh water side of condensers. In some of the older condenser plants the chlorine (chloride) content of the condensate usually is constant and not greater than 0.2 grain per gallon. In most existing condenser installations, the condensate consistently contains no more than 0.1 grain of chloride per gallon. Any consistent increase above these values is a definite indication of a leak. When a leak is detected it should be corrected as soon as operating conditions will permit disabling the unit affected. Attention is directed to appropriate parts of the Chapter of Bureau of Ships Manual for operation and maintenance of condensers.

*Items (1), (6), and (7) apply only to boiler feed water.

Leaky evaporator tubes occasionally are responsible for salting up the feed system. The salting up usually occurs after the evaporators have been secured when a leak in the first effect tube nest drains and eventually some parts of the feed system. Therefore, the tube nest drains should be tested for salinity upon starting up the evaporator plant. It is possible, through faulty evaporator operation, to permit the level of the brine in the shells to rise to the point where salt water backs up through the first effect tube nest vent line, thus contaminating the drains. The first effect tube nest drain line should be secured during all periods when the evaporators are idle.

The system may be salted up by leaky feed suction lines which run through the bilges. Such leaks will also be responsible for some loss of make-up feed water. Periodic tests of feed suction lines should be made, as very often leaks will exist which are responsible not only for a loss of fresh water, but for loss of pumping efficiency when the lines are being used.

No cross-connections shall be permitted between the salt water and fresh water piping.

Before shifting feed water suction from one reserve feed tank to another, the water in the new tank should be tested for hardness and chloride. Water having hardness greater than 2.0 grains per gallon shall not be used as make-up feed. Normally the hardness should not exceed 1.0 grain per gallon. Water having a chloride content greater than 1.0 grain per gallon shall not be used as make-up feed, except in emergency. Normally the chloride content of make-up feed should not exceed 0.5 grain per gallon.

38. Operation of Stills When Overboard Water is Contaminated.

(a) With regard to safety precautions for protection of the potable water when the vessel operates in polluted water areas, the Manual of Instructions, Bureau of Ships, states, in chapter 58:

(a) When evaporators are operating in contaminated water, unsterile water may be produced either by priming of the water in the shells or by leakage of contaminated water into the distillate in the distilling condenser or in one of the heaters through which the distillate passes in either the vapor or liquid form.

(b) In order to produce sterile water in areas where the sea water may be contaminated, evaporators should be operated with great care to avoid any priming, and if priming occurs, this water must not be sent to the ship's tanks. Frequently inspections and tests should be made of the distilling condenser and other units through which the distillate passes to insure that the water is not contaminated by direct leakage from the cooling water to the distillate.

(c) Vessels should consider that they are operating in contaminated sea water when they are operating in, or in the vicinity of, harbors, rivers, and lakes.

(d) If at any time there is good reason to believe that unsterile water is being distilled for ship's use, low pressure plants

should be operated at a low distilling rate and the pressure maintained at a point that will insure a temperature of 200°F. in the first effect shell. In addition to the above precautions as to first effect shell temperature for low pressure plants, it should be determined definitely that absolutely no cooling water leakage occurs in the distilling condenser or any other heat exchanger through which distillate or vapor passes regardless of the type of plant with which the vessel is equipped.

(b) The maintenance of an elevated brine temperature as suggested in subparagraph (d) above, disinfects the brine after it has entered the evaporator shell and thus prevents contamination of the distillate when water droplets are carried over; that is, when the still primes. Elevation of the brine temperature does not provide protection against contamination by leakage in the distilling condenser and some of the other heat exchangers in an evaporation plant. Bacteriological studies indicate that heating water to a temperature of 165°F. will kill all intestinal pathogens Thus, raising the first effect brine to any temperature above 165°F. protects against contamination by priming only.

(c) For further discussion of priming and leakage in distillation plants see the Bureau of Ships Manual of Instructions, chapter 58.

39. Chloride Tests.--Stills are equipped with numerous salinity cells all wired to a single resistance measuring device and are so located that the probable place of leakage of priming can be determined at once when chlorides appear in the distillate. Chapter 58 of the Bureau of Ships Manual of Instructions contains complete directions for cutting out various parts of the unit and conducting tests to locate trouble. The distillate should be tested for chlorides at least every 15 minutes and if the overboard water is polluted, the distillate must not be sent to the fresh water tanks when there is any indication of leakage or priming. When the ship is in fresh water the salinity test is a much less sensitive indicator of contamination in the distillate. Sea water contains about 37,000 ppm dissolved salts while fresh water may contain less than 200 ppm dissolved salts. Thus for equal effects on salinity under these conditions the leakage indicated would be about 200 times as great in fresh water as in salt water. This is not of particular importance as far as boiler feed water is concerned, but it should be a matter of considerable concern to the medical officer when the salt test alone is used as an indicator of probable bacteriological contamination. One grain per gallon may be expressed as 17.1 PPM.

Section VIII.--DISINFECTION OF SHIP'S WATER

40. Disinfection.--Water is usually disinfected by the addition of sufficient chlorine compound to produce a residual

of not less than 0.2 ppm free chlorine after a 20-minute contact period. This contact period can be reduced to some extent by use of higher residuals. The chlorine must come in contact with all particles of water for the required contact period prior to delivery of the water for use. The chlorine dose is controlled by testing the residual chlorine in the water after the required contact period has elapsed. A standard chlorine residual testing kit is used for this purpose.

41 Need for Disinfection.

(a) The ship's fresh water should be disinfected whenever there is any indications of contamination. Disinfection is also recommended as a routine method of guarding against the sanitary defects or accidents that may occur during the production, handling, storage, and distribution of water, particularly when the vessel is in or near polluted harbors. Such use of disinfection should be considered as providing an added factor of safety and not as constituting a satisfactory substitute for the correction of sanitary defects or insanitary practices.

(b) Routine chlorination has several advantages over the practice of chlorinating water only when need for it is indicated by bacteriological analysis or by the presence of enteric disease. Bacteriological examinations must be conducted by especially trained medical personnel who have complete laboratory facilities at their disposal. The tests involve a one or two-day incubation period which seriously delays the results. In fact the time consumed and the difficulty of properly sampling and testing water for bacteriological quality is such that it would be very difficult to provide adequate testing facilities for all ships at all times. On the other hand the test for free chlorine residual is simple and accurate and can be made in about five minutes. Water that is properly chlorinated is safe water and bacteriological analyses are unnecessary except as occasional checks.

42. Chlorine Compounds.

(a) Written permission from the Bureau of Ships is required before chlorine gas may be carried and regularly used aboard naval vessels. Chlorine gas is heavier than air and in the event of a leak or damage to a gas cylinder as a result of enemy action, chlorine might flood the lower hull spaces before protective measures could be taken. Therefore, a chlorine liberating compound is used, ordinarily Grade A calcium hypochlorite (HTH, Perchloron, etc.).

(b) Grade A calcium hypochlorite originally contains 60 to 70 percent available chlorine. The compound loses strength gradually with age, however, especially when stored in a hot space. Hypochlorites should be purchased in small containers,

usually three pounds, stored in a cool, ventilated place, and analyzed every few months or before use to determine the chlorine content of the powder. About 1/5 of an ounce of full strength Grade A hypochlorite is required to dose 1,000 gallons of water with 1 ppm of chlorine. Solutions for machine feeding may be from 1 to 10 percent strength. The solution should be made up and allowed to clarify, and then should be decanted.

43. Batch Chlorination.--Water may be chlorinated in the potable water tanks by the batch method. The required amount of chlorine compound is dissolved in a bucket of water, and introduced into the tank when it is about one-quarter full. Sufficient mixing usually will be obtained by the stirring action of the incoming water as the tank is filled. Additional mixing may be obtained by recirculation. If the chlorine solution must be introduced into a full tank, mixing by recirculation through a pump is necessary. Twenty minutes or more after the tank is filled or mixing is completed, the water is sampled and tested for residual chlorine. If the residual is less than 0.2 ppm, more chlorine must be mixed into the water and after the required contact period the residual must be measured again.

44. Mechanical Chlorination.--Hypochlorinators which inject chlorine solution in proportion to the flow of water have been adapted to shipboard use. These may be used to chlorinate water entering the potable water tanks or may be installed to inject chlorine solution into the water as it enters the distribution system. Chlorination of the water as it enters the potable water distribution system provides a greater degree of safety but requires the installation of a holding tank to assure the necessary contact time.

45. Testing for Residual Chlorine.--An ortho-tolidine chlorine test kit is used to determine chlorine residuals when disinfecting water. In the most commonly used type of kit the color develops when ortho-tolidine is added to water containing free chlorine. The water is compared with glass color disks to obtain a reading. The unit includes the 15 ml. sample cells, a bottle of ortho-tolidine with dropper large enough to deliver in one dose the required amount of ortho-tolidine, a circular frame mounted with color disks, a comparator with binocular eyepiece, and instructions for use. The instructions may call for reading the color five or more minutes after adding the ortho-tolidine; however, the color should be read within 10 seconds after the ortho-tolidine is added. The reason for this is that the five-minute reading gives what is called the total residual which includes free chlorine, chloramines (chlorine-ammonia compounds), and interfering substances such as iron, manganese, and nitrites. The 10-second reading gives only

free chlorine. The 10-second reading (flash test) is most sensitive at lower temperatures. At 100° F. the difference in speed of color development is barely readable. The measurement of only the free chlorine is important because of the fact that for equal concentrations and contact times free chlorine is about 30 times as effective as chloramines.

46. Chlorine Doses.

(a) The chlorine dose required to produce a 20-minute free chlorine residual of not less than 0.2 ppm varies widely. This is true even for distilled water. To obtain a free chlorine residual in distilled water sufficient chlorine must be added to destroy the ammonia. This requires a chlorine dose in ppm of at least 10 times the ppm of ammonia (measures as nitrogen) present in the water. Unfortunately the ammonia in sea water goes over into the distillate and since the ammonia in natural water varies widely, the ammonia content of distilled water also may be expected to vary.

(b) In the absence of information concerning the amount of ammonia and other chlorine demanding substances in water, a dose of not less than 1 ppm chlorine should be used initially. If this does not produce a free chlorine residual of 0.2 ppm after 20 minutes' contact, more chlorine solution must be added. If desired, the chlorine demand or the dose required can be determined by adding various amounts of chlorine solution of known strength to samples of the water to be treated. Determination of residuals in these samples after 20 minutes' contact will indicate the proper dose.

(c) When weighing the chemical for batch chlorination of water it is convenient to remember that one ounce of Grade A, full strength calcium hypochlorite (HTH, Perchloron, etc.) added to 5,000 gallons of water, or one pound to 80,000 gallons, gives a dose of 1 ppm of chlorine.

Section IX.--STANDARDS OF QUALITY

47. Standards.--Details pertaining to the various bacteriological and mineral standards for drinking water appear in Section IV of the chapter on "Water Supply Ashore." Bacteriological standards are of two types: (a) standards for certifying public supplies on the basis of numerous past laboratory analyses, and (b) standards for judging the current safety of a supply for individual test results. Type (a), of which the United States Public Health Service standards are an example, are pertinent to the problem of water supply afloat only insofar as they are used to certify shore supplies which may be taken aboard. Standards based on averages determined by the accu-

mulation of data over an extended period, however, are of no value for judging the safety of the potable water in a ship's tanks because of the fact that ship's water may be produced or taken aboard in different places under a variety of circumstances. The current safety of a ship's supply must be judged from each individual test.

48. Bacteriological Analyses of Potable Water.--The bacteriological examinations of most value are:

(a) The quantitative estimation of organisms of the coliform group.

(b) The count of total colonies developing on the agar in 24 hours at 37° C. Of these, the test for the coliform group is the more significant because it affords a specific test for the presence of fecal contamination.

49. Water Testing.

(a) The engineering department of a naval vessel is fully equipped to test water for the presence of chlorides and other common minerals. See Chapter 56, Bureau of Ships Manual.

(b) In general, water analyses should be made in accordance with instructions in the latest edition of "Standard Methods for the Examination of Water and Sewage," American Public Health Association.

(c) Any medical bacteriological laboratory whether ashore or afloat which has lactose broth and inverted vial fermentation tubes can perform bacteriological tests of potable water. To make the test, transfer aseptically five 10 ml. portions of a water sample to each of five fermentation tubes containing either 30 ml. of nutrient lactose broth or 10 to 12 ml. of double strength nutrient lactose broth and incubate for 24 hours at 37° C. The formation of gas in the inverted vial is presumptive evidence of the presence of coliform organisms. If the necessary special media are available, the analysis may be carried one step farther and the confirmed test made, using either EMB agar or brilliant green lactose bile broth. Water samples are sometimes planted directly in brilliant green lactose bile broth or in methylene blue erythrosine bromcresol purple broth. These are not standard methods. They do, however, have the advantage of saving time by producing in one step results which are essentially the same as those obtained by use of the standard presumptive and confirmed tests.

50 Interpretations.

(a) The object of testing water is to make sure that coliform organisms are not present. This is quite a different approach from the usual diagnostic procedure of undertaking

to demonstrate that a specific organism is present. In water testing the safety is greater when the test interpreted as positive is less specific. Experience suggests that when water has been chlorinated no serious hardship is imposed by considering a positive presumptive test as an index of fecal contamination. The appearance of gas in the presumptive tests is a sign of undesirable possibilities.

(b) The United States Public Health Service standards for drinking and culinary water supplies by common carriers in interstate commerce require that the average coliform density be less than 100 ml.

(c) An occasional positive tube among the five portions constituting a standard sample might not be considered of much significance. If the majority of the portions are positive, however, the supply should be investigated, the water meanwhile being considered unsuitable for use unless subsequently chlorinated or boiled.

(d) Plate counts exceeding a reasonable maximum require explanation. In waters that have been chlorinated plate counts of over 200 colonies per ml. suggest sanitary defects even though tests for coliform group are negative.

51. Potable Water Bacteriological Standards.

(a) On the basis of the foregoing information and with regard for the fact that it is better to chlorinate water that may not need it than to risk drinking water which may be contaminated, specific standards are suggested below. The standards are based on the 37° - 24-hour plate count and on primary plantings of five 10 ml. portions of a sample in five fermentation tubes containing one of the following liquid culture media: lactose broth, brilliant green lactose bile broth, or methylene blue-erythrosine bromcresol purple broth. Lactose broth is the least specific of the three and, therefore, gives the greatest degree of safety. Fermentation tubes should be observed every few hours for the appearance of gas.

(b) The suggested standards are set forth in the form of recommendations to be used when reporting findings to the ships or ship's officers concerned. They are:

(1) When the 37° C. - 24-hour plate count is less than 200 bacteria per ml. and not more than one of the five 10 ml. portion fermentation tubes has produced gas after 48 hours, report:

Water satisfactory.

When the 37° C. - 24-hour plate count is more than 200 bacteria per ml. and not more than one of the five 10 ml. portion fermentation tubes has produced gas after 48 hours, report:

High bacterial count evidence of faulty water sanitation.

Chlorination in Tank No. desirable.

When gas appears in more than one of the five 10 ml. portion fermentation tubes at any time within 48 hours continue to observe tubes but immediately report by most rapid means available:

Water test indicates possible sewage contamination.

Advise chlorination in Tank No. ________.

When gas appears in all five 10 ml. portion fermentation tubes at any time within 48 hours immediately report by most rapid means available, even if an earlier report has been forwarded in accordance with (3) above:

Water test indicates sewage contamination.

Advise closure of Tank No. _____, chlorination, and retest before use.

(c) When laboratory facilities and time are available, bacteriological tests should also be conducted in accordance with "Standard Methods" and the actual 37° C. - 24-hour plate count and the most probable numbers (MPN) of members of the coliform group determined. These data, if obtained, should be forwarded to the ship and also entered in the regular reports to the Bureau of Medicine and Surgery. If high plate counts or gas formation indicates faulty sanitation, however, the recommendation to chlorinate should not be delayed until tests by "Standard Methods" are complete.

(d) Also test water drawn from scuttlebutts and faucets.

52. Bacteriological Standards for Salt Water.

(a) Bacteriological tests are too slow to be used directly for determining the time and place where the use of overboard water in galleys, showers, etc., should be prohibited. The tests require 24 to 48 hours but a vessel may move from uncontaminated into highly contaminated water in an hour. Rules based on distance off shore or on fathom lines are unsatisfactory for two reasons: (1) They usually are formulated without reference to bacteriological data; and (2) an overboard system which has been heavily contaminated may not be flushed clean for some time after a vessel has put to sea.

(b) It is evident, therefore, that judgment must be depended upon in deciding when it is unsafe to use water from the overboard system for purposes involving health hazards. In order to enlighten judgment, however, it is suggested that whenever possible bacteriological data be accumulated by analyzing water from the overboard system as the vessel approaches or departs

various types of harbors, and when the vessel is operating in fleet concentrations. The tests and interpretations should be as follows:

(1) Plant five 10 ml. and five 1 ml. portions of each sample in either lactose broth, brilliant green bile broth, or methylene blue-erythrosine bromcresol purple broth and incubate at 37° C.

(2) The use of overboard water in vegetable peelers and in galley, scullery, and other food preparations spaces should be prohibited and the salt water lines disconnected whenever the probable quality of the water as judged from past experience is such that more than two of the 10 ml. portions may be expected to show gas within 24 hours.

(3) The use of overboard water in showers, laundries, and for flushing decks should be prohibited whenever the probable quality of water as judged from past experience is such that more than two of the 1 ml. portions may be expected to show gas within 24 hours.

(c) All data obtained relative to the quality of overboard water should be forwarded to the Bureau of Medicine and Surgery in the regular sanitary report together with pertinent information as to the places where and the conditions under which samples were taken.

53. Chemical Standards, Sampling, Shore Laboratories, Etc.--For information on these subjects reference should be made to Chapter V, Section IV, "Water Supply Ashore."

Chapter 7

Waste Disposal

Section I.--INTRODUCTION

1. Purpose of Waste Disposal. - The proper disposal of waste materials is one of the important measures for the control of the intestinal and insect-borne diseases. Waste disposal must accomplish the following:

(a) Destruction or the safe disposal of material which may contain pathogenic organisms.

(b) Destruction or prevention of breeding of insects and rodents that spread disease.

(c) Removal or prevention of conditions offensive to the senses.

2. Classification of Waste. - The wastes to be disposed of may be classified as:

(a) Human excreta (feces and urine).

(b) Liquid waste or sewage (scullery, galley, bath, laundry and flush toilet wastes).

(c) Refuse (garbage and rubbish).

3. Responsibility for Disposal.

(a) The commanding officer is responsible for sanitation within all areas under his jurisdiction. He issues the orders and provides the personnel necessary to assure sanitary disposal of wastes. When wastes must be transported and disposed of outside the area under his jurisdiction the commanding officer should make sure that no health hazard is created and that the disposal of wastes will not interfere with subsequent expansion of military operations.

(b) Prior to combat operations the senior medical officer recommends a program for sanitary waste disposal suitable for the proposed operations. The program shall include plans for indoctrination of officers and men, plans for obtaining, loading and unloading knockdown equipment, and plans for setting up waste disposal facilities at the earliest possible moment and

for their proper operation and maintenance. The medical officer should consult with the commanding officer and the Public Works or engineer officer as necessary to assure that the proposed program can be effectively executed. He should prepare for the approval of and issue by the commanding officer the sanitary orders required to carry out the program.

(c) Prior to and during combat operations the medical officer must do the planning and make all arrangements necessary to assure proper disposal of wastes. He is the key member in the three man team -- commanding officer, medical officer and Public Works or engineer officer. However, when the development of a permanent or semi-permanent base or camp is under taken, the more complicated nature of waste disposal facilities needed requires that the engineer or Public Works officer assume the job of planning and building sanitary works. The engineer then becomes the key man who advises the commanding officer after consultation with the medical officer. This shift in responsibility must be clearly understood and agreed upon in the field. In any case the medical officer will inspect the operation and maintenance of waste disposal systems in so far as these affect the health of personnel and will advise the commanding officer concerning the need for improved operation or for additional facilities.

(d) The Public Works officer or the Marine Engineer Battalion Officer is responsible for the planning, design, construction, operation and maintenance of waste disposal systems in all established shore-based activities. As described above, when an occupied area is to be developed into a semi-permanent camp or an advanced base, the engineer or Public Works officer shall take over from the medical officer, by definite agreement between the two and the commanding officer, the responsibility for advising, planning, building and operation of waste disposal facilities.

Section II.--HUMAN EXCRETA

4. General. - On the march or during temporary encampment, the simplest possible sanitary methods of waste disposal must be utilized. If an occupied area is to be used for establishment of a semi-permanent base, the sanitary facilities must be improved as rapidly as possible. Well developed advanced bases may have sewage and waste disposal systems comparable to those of an American city.

5. Emergency Disposal.--During brief halts on the march, or on initial landings, men who desire to relieve themselves should dig a hole with an entrenching tool or bayonet, and after

depositing feces should cover them with several inches of earth. All men should carry a supply of toilet paper with them in the field. During a halt for a meal a sanitary detail should be assigned to dig latrines immediately. Narrow trenches eight inches or more in depth and one foot wide suffice. These should be confined to as small an area as possible and their location should be pointed out to the men before they fall out after the march. Non-commissioned officers should be held responsible for policing, or a guard should be posted to make sure these facilities are used properly. When the column is again on the march, the sanitary detail remains to fill in the trenches with earth and mark their locations.

6. Latrines.

(a) Latrines should be located adjacent to the company area. They are generally a company installation and are maintained by the respective companies. Latrines should be located on the side of the camp area opposite the galley and mess hall. Drainage from the latrine into a source of water supply must be avoided. Latrines should be located on well drained ground and protected by a ditch which will prevent flooding or damage during heavy rain storms. On small islands latrine locations should be limited in number and carefully selected to avoid interference with future development of the available camp areas. A sufficient number of latrine seats or spaces should be installed to provide one seat for each 10 - 20 men; depending on size of unit. Separate latrines should be constructed for officers and for enlisted personnel. A lighted lantern can be hung at each latrine at night unless military situation demands concealment. When pits are filled to within 18 inches of ground surface or are to be abandoned, the pits should be thoroughly sprayed, the excavation backfilled, the surface mounded over to allow for future settlement, and the military situation permitting, should be placarded showing the date and organization.

(b) Straddle trenches. - Straddle trenches are used in bivouac, in camps less than one week duration, or until deep pit latrines can be constructed in camps of longer duration. The straddle trench is constructed by digging a trench 1 foot or less in width, 2 feet deep and 3 to 10 feet long. Adjacent trenches should be 3 feet apart. The earth removed should be piled at the ends of the trench, leaving a foothold on each side which can be improved if necessary by planks. A can or shovel, placed on the piles of earth, must be used by each man to cover his excrement. Toilet paper should be protected by cans or canvas during rainy weather. In inhabited localities the trenches should be screened from vision. Straddle trenches are filled within one foot of the

ground surface, they should be sprayed, (see Paragraph 11) filled and mounded over with earth.

(c) Deep pit latrines.

(1) Deep pit latrines are used in temporary camps and may be used on bases of a semi-permanent nature. Great care must be exercised in their construction and maintenance, otherwise the latrine will be a menace to health.

(2) A fly-tight box is an absolute necessity. It may be made "knock-down" in type, assembled and stored prior to use and after use may be taken apart and easily moved. A prefabricated portable latrine box developed by the Marine Corps is shown in fig. 7-1. The box folds and is light enough to carry ashore during landing operations. It can be erected very quickly without the use of tools. The 4 hole units may be bolted end to end to provide latrines with any multiple of 4 seats. The pit for these boxes should be 32 inches wide by 4 feet long.

(3) A latrine which is to be used less than one week should be dug 3 feet deep. One foot depth should be added for each additional week of anticipated use. Field tests have shown that in ordinary soil bacteria can travel only a very short distance from the pit, even when the pit penetrates the ground water. Where the ground water flows through very porous gravel or in open cracks, crevices, and caverns in limestone, coral or volanic rock penetrated by the pit, ground water pollution may be serious. Fly breeding is prevented and digestion of solids is improved by using deep pits penetrating well below the water level in the ground. A clam shell bucket is useful in excavating such pits. If soil near the surface is loose or sandy, as is ordinarily the case, pits have to be cribbed with poles or planking to prevent cave-ins. Oil drums with one or both ends removed make excellent cribbing. If possible, one drum should be used under each seat. Pits may be constructed by blasting a hole, then setting in and backfilling around the crib. If ground water is very near the surface a crib may be set up on the surface and a bull dozer used to mound soil around it. An elevated pit latrine results.

(4) Where fly breeding is not prevented by the depth of the pit or by the use of chemicals, the ground around the pit must be treated to prevent the escape of larvae. The interior of the pit and an area four feet wide surrounding the pit should be dusted or sprayed periodically with DDT. If there is an opening in the box for ventilation, this opening should be covered with a screen, and the screen should be

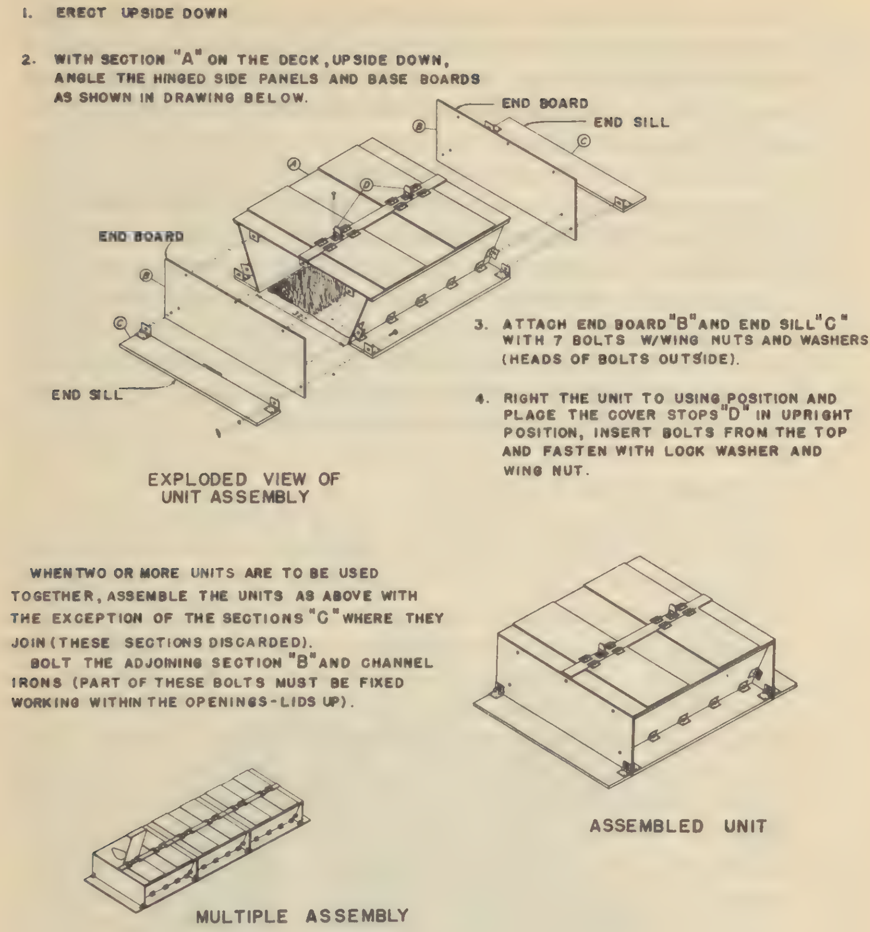
1. ERECT UPSIDE DOWN
2. WITH SECTION "A" ON THE DECK, UPSIDE DOWN, ANGLE THE HINGED SIDE PANELS AND BASE BOARDS AS SHOWN IN DRAWING BELOW.
END BOARD
END SILL
A
B
C
D
END BOARD
END SILL
3. ATTACH END BOARD "B" AND END SILL "C" WITH 7 BOLTS W/WING NUTS AND WASHERS (HEADS OF BOLTS OUTSIDE).
4. RIGHT THE UNIT TO USING POSITION AND PLACE THE COVER STOPS "D" IN UPRIGHT POSITION, INSERT BOLTS FROM THE TOP AND FASTEN WITH LOCK WASHER AND WING NUT.
EXPLODED VIEW OF UNIT ASSEMBLY
WHEN TWO OR MORE UNITS ARE TO BE USED TOGETHER, ASSEMBLE THE UNITS AS ABOVE WITH THE EXCEPTION OF THE SECTIONS "C" WHERE THEY JOIN (THESE SECTIONS DISCARDED).
BOLT THE ADJOINING SECTION "B" AND CHANNEL IRONS (PART OF THESE BOLTS MUST BE FIXED WORKING WITHIN THE OPENINGS-LIDS UP).
ASSEMBLED UNIT
MULTIPLE ASSEMBLY

Figure 7-1

painted every 3 or 4 weeks with DDT solution. All cracks in and around the box must be made fly-tight by strips of wood or cloth packing. After the latrine box is placed over the pit, oiled or moistened earth should be tamped tightly around the perimeter of the box.

(5) The latrine should be enclosed from view by a screen made of canvas or other material and if possible protected from the rain by the use of a tent or other covering. If enclosed, provision should be made for ventilation, with all openings made insect proof. Doors should open outward. A drainage ditch at least 6 inches deep should be dug around the latrine enclosure and connected with a drainage channel to carry off surface water. Flooding of the pit by run-off of heavy rains must be guarded against.

(d) Other types of latrines.

(1) Pail latrines should be used only where it is impossible to construct a pit, for example, where the ground is flooded or frozen. A pit type latrine box may be adapted for use as a pail latrine. Strips are nailed to the floored box to spot the pail and a metal deflector provided to direct urine into the pail. When located in a building, the latrine should be arranged so that the pails can be removed from the outside of the building through hinged openings in the wall. The pails should contain about one inch of a two percent cresol solution, and they should be removed at least twice daily and replaced by clean pails. The excreta may be disposed of by burial or by dumping into a sewer system. Pail latrine systems are difficult to maintain in a sanitary condition.

(2) Bored-hole latrines have been used extensively in the Far and Middle East. These consist of a round hole, 14 to 18 inches in diameter and 15 to 20 feet deep made with a post-hole auger. This type of latrine has the advantage of being almost flyproof due to its depth. A temporary flyproof cover may be used with the hole latrine, or a seat may be installed. If conditions warrant, a permanent structure should be placed over the latrine.

7. Urine Soakage Pits and Trenches.

(a) Separate soakage pits or trenches should be used to dispose of urine. The pit shown in fig. 7-2, will dispose of the urine of 200 men. This pit is about 4 feet square and 4 feet deep and filled with pieces of broken stone (1 to 4 inches in diameter), flattened tin cans, brick or broken bottles. Ventilating shafts shown in fig. 7-2 are of little value in reducing odor, and if used as urinals, often increase it. A soakage pit will work just

as well without them. Odor is best controlled by making the funnels small and avoiding all points where old urine might collect above ground. Crushed stone or other material to provide large spaces, is used to fill the pit. This should be covered with oil soaked burlap and then covered with earth. Soakage trenches are suitable where soil near the surface will absorb urine and where it is not desirable or possible to excavate to a four foot depth. They consist of a central pit 2 feet square and one foot deep with trenches radiating from each corner. These are one foot deep and one foot wide at the pit and slope to a depth of 18 inches at the outer ends. Length of trenches is usually about six feet, but may be longer, if required. As in the case of soakage pits, trenches are filled with broken stones, bricks, etc., then surfaced with oil-soaked burlap and covered with earth. When the soakage pits or trenches are abandoned,

Figure 7-2.--Urine soakage pit

all appurtenances should be removed and the openings filled with earth.

(b) When the soil is pervious or can be made pervious by blasting, it will serve as a natural soakage pit without further preparation. Urinal piping should extend at least one foot into the pervious material. A large diameter pipe set into sand is quite unsatisfactory, however.

8. Urine Trough and Funnel Connections.

(a) Urine troughs may be mounted directly above soakage pits or may be erected in an adjacent enclosure and connected to the pit by means of suitable piping. If a latrine pit is located in unusually porous ground, troughs may be connected thereto in lieu of constructing separate urine pits. However, urine in the latrine pit causes offensive odors so should be kept out if possible.

(b) A urine trough may be constructed of tinned or galvanized iron, or of wood. If made of wood, it should be lined with tar paper and made water tight. The trough should be "U" or "V" shaped in cross-section and sloped toward the outlet so that it will drain completely. The outlet should be protected by a wire-mesh insert to prevent foreign material from entering and clogging the drain piping. Length of trough should be approximately 10 lineal feet per 100 men.

(c) Where the facilities are for 50 men or less, connections to the pit may be 2-inch drain pipes terminating at the top in funnel inlets. Funnels may be of metal or tar paper. They should be protected against clogging by a wire-mesh insert or filled with grass or straw. Large areas exposed to urine make the odor problem worse. Funnels should be as small as practicable.

9. Night Urinals. - If the distance to the latrine is considerable, a large can or pail containing one inch of cresol solution should be placed close to the living quarters. Each morning the contents of the can should be poured into the soakage pit and the can cleaned and sunned during the day.

10. Maintenance of Latrines and Urinals. - Latrines, urine troughs and pails must be maintained in a sanitary manner. To insure this condition a latrine orderly should be placed in charge. The following are particularly important:

(a) Keep the box fly tight.

(b) Keep the lids closed.

(c) Scrub the seats and urine troughs daily with soap and water and twice weekly with a disinfectant.

(d) Treat the pit with Para-Dichlorobenzene (PDB), or spray with sodium arsenite or with DDT twice weekly or spray the pit with oil daily. Burn out the paper twice weekly. To do this

sprinkle the contents with a little kerosene or Diesel oil (not gasoline) to give a low fire when ignited.

(e) Do not contaminate the seats with oil or poisonous insecticide solutions used to treat the pit.

(f) Supply ample toilet paper.

(g) Keep the enclosure fly-tight. Paint all screens once a month with DDT solution.

11. Control of Fly Breeding in Latrines. - The following treatments have been used with success to reduce or prevent fly breeding in the ordinary type pit latrine.

(a) Paradichlorobenzene (PDB), 1/4 inch granular. Add eight (8) pounds initially to an eight (8) seat latrine and 2 to 2 1/2 pounds twice a week thereafter. The chemical forms a layer of gas which acts as a larvicide and keeps adult flies out of the latrine. This method requires no equipment, is safe and quick, and is highly effective in dry pits of sufficient depth if boxes are tight enough to prevent rapid escape of the chemical vapor. Catalog of Navy Material, Stock Nos. are 51-D-190 and 51-D-192, Dichlorobenzene, para (PDB) 1 lb. can and 100 lb. drum. It is generally not as useful on permanent stations as DDT.

(b) Sodium arsenite solution. Spray the pit twice weekly with a solution consisting of concentrated sodium arsenite solution (Penite) diluted 1 to 40 with water or of 10 pounds of sodium arsenite powder dissolved in 100 gallons of water. Sodium arsenite solution is highly effective against both larvae and adult flies under nearly all conditions found in latrines. The concentrate is the least bulky of the effective insecticides and can be diluted with any kind of water. Since sodium arsenite is highly toxic to man it must be handled with care and must be kept off the latrine seats. A further objection is the danger of contaminating ground water supplies. Stock No. of the concentrate is 51-S-2333, Sodium arsenite, 54% solution, 30 gal. drums.

(c) DDT. Treat the pit with one quart per week per seat using a 5% solution of DDT in kerosene or Diesel oil. The method is effective in a dry pit. Spray the solution over the pit contents and the inside of the pit and box. Residual spraying of the latrine hut will further relieve fly difficulties. For details concerning the use of DDT see Chapter 9.

(d) Fly Sprays. Standard fly sprays are not recommended because of the superiority of DDT sprays applied for residual effect. New insecticides, such as chlordane, may be superior to DDT in some situations.

(e) Oil. The pit contents, the inside of the box and the ground around the latrine may be oiled daily to keep down fly breeding.

Latrine oil usually consists of 3 percent cresol in Diesel oil or in a mixture of kerosene and fuel oil. It is not very effective, and very large quantities are required.

12. Chemical Toilets.

(a) Chemical toilets offer a sanitary method of disposal of feces. Operation of this type of toilet depends upon the action of caustic soda and water, which not only kills all the bacteria but also liquifies some of the solids. The tank is charged with 25 pounds of caustic soda for each seat and is filled with water to above the lower edge of the drop tube agitator, and manhole shafts. This forms a water seal and prevents escape of odors. After use, the lid of the bowl should be closed and the agitator operated several times in order to mix chemical and excreta. If the drop-tube becomes spattered with diarrheal excreta, it must be flushed down with dilute cresol. Proper charging with caustic soda, maintaining a high enough water line to form a seal, and agitating after use are essential for good operation. The period of use before emptying and recharging becomes necessary should be several months, will probably be less.

(b) If no gravity drain is provided, the tank must be emptied by bailing or pumping. At some advance bases a tank truck equipped with a pump is assigned to this duty. The contents should be buried or barged to sea. Wastes from a chemical toilet must not be placed in septic tanks.

13. Waste Water Flush Type Facilities. - The most sanitary method of removing human wastes from the vicinity of habitations is flushing into a sewerage system. However, flush type toilets are frequently not available on advanced bases or the supply of water is too limited to be used for flushing toilets. The waste water automatic flushing latrine is suitable under these conditions. In this latrine waste shower and lavatory water is used to flush the excreta from a channel under the latrine box. When a 225-gallon dosing tank is filled by flow from the showers and lavatories, an automatic siphon discharges the tank contents into the latrine channel. The flushing action of the water carries the excreta into the sewer system. A dam near the outlet end retains about 5 inches of water in the channel at all times. A latrine of this type could be improvised using almost any type of building material. Standard design details appear on Y&D Drawing No. 283,369.

Section III.--LIQUID WASTE OR SEWAGE

14. Liquid waste or sewage includes water from showers, lavatories, galley, scullery, and also from flush toilets, whenever installed. The amount of water used in these facilities deter-

mines the quantity of sewage to be disposed of. Where the volume of waste is small and the soil is pervious, sewage may be passed through settling tanks and disposed of by absorption in the soil. As water supply facilities are enlarged, water consumption, and hence liquid waste, increases to a point where it cannot be disposed of in this manner. Under these conditions a system of pipes or sewers may be required to convey the waste liquids to a point where they can be disposed of into a natural body of water. When required, sewage must be treated or altered so that it may be disposed of without creating a nuisance or menacing health.

15. Grease Traps.

(a) Liquid wastes originating in the galley or scullery contain a large amount of fat or grease. This congeals upon cooling and clogs drain lines and absorption areas and causes excessive scum formation in settling tanks. For this reason wherever possible galley and scullery wastes should be disposed of by a system which is entirely separate from that used for disposal of other liquid wastes. Grease traps may be of the baffle or filter type.

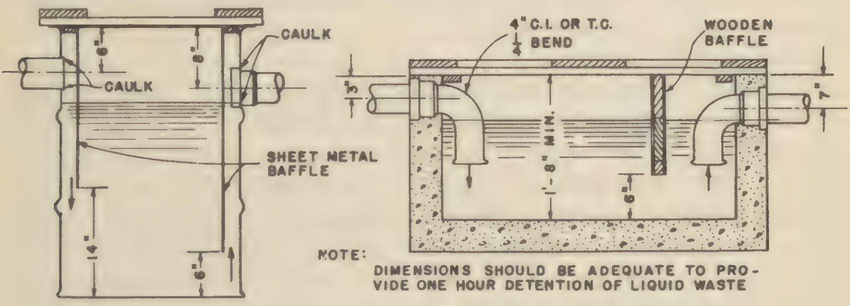

Figure 7-3.--Grease traps

(b) Baffle type.

(1) The baffle type grease trap may be improvised from an oil drum or wooden barrel or may be made of concrete, steel or wood. (See fig. 7-3) A fly-proof cover is essential. A baffle extending to within several inches of the bottom divides the container into unequal chambers, the largest being the grease chamber. The outlet should be placed about eight inches below the upper edge of the container, and the inlet should be four inches above the outlet. When warm galley waste mixes with the cooler water in the trap, the grease congeals and rises to the surfaces where it is retained by the baffle. Cooling is improved by sinking the trap into the ground. Grease traps are usually too small.

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(2) The congealed grease or scum should be skimmed daily and buried or burned with wood. The grease trap should be completely emptied and scrubbed with soap and water when odors begin to develop or when the bottom sludge has reached a depth of a few inches. Liquid wastes containing fecal matter should never be passed through a grease trap.

(c) Filter-type. The function of this trap is to strain or filter out grease and other matter which would readily clog the soil. The filter is generally constructed from an oil drum or wooden barrel with the upper end removed. The bottom is perforated and the drum is filled with 6 inches of gravel or crushed stone followed by 18 inches of coarse sand, wood ashes or coral. If the liquid waste has not been previously strained to remove the coarser particles, a burlap covering should be placed over the top of the barrel for this purpose. A basket type strainer can be constructed by perforating the bottom of a pail or other metal container and filling it with grass, hay or straw. The filter and strainer media must be removed and replaced as soon as they become clogged. Burlap strainers should be washed daily. Used filter or strainer material should be buried or burned to prevent nuisance.

16. Sewers.

(a) Design. Sewers are usually constructed of vitrified clay tile, concrete, or cast iron pipe. They should be laid on slopes which will provide self-cleaning velocities of 2 to 3 feet per second. The joints should be carefully sealed to prevent leakage from the sewer or seepage of ground water into the sewer. Manholes are constructed at the upper end of each lateral, at each change in direction and grade, at sewer junctions and at not more than 400-foot intervals on straight runs. Sewage is carried through manholes in open channels formed into the concrete manhole bottoms. Sewer pipe should always be laid on firm foundation in a straight line and on a uniform gradient and should have four feet or more of cover to provide protection from traffic and frost. Sewers should be inspected regularly for broken sections, clogging or other defects and should be maintained in proper operating condition. A lamp and mirror are useful for inspecting sections of sewer between manholes.

(b) Concrete pipe forms. Forms to fabricate concrete pipe are now available for advance base use. These will permit wider use of the sewer system as a method of disposal of liquid waste. Stock forms include 6", 10", 18" and 24" diameters, but other sizes can be obtained. Joints are of the tongue and groove type and can be made with cement mortar. Where fresh (not septic) wastes are handled, no surface protection is required.

Sewage can be maintained in a fresh condition by using proper sewer gradients.

17. Settling Tanks.

(a) A settling tank is a basin, usually reinforced concrete, through which sewage is directed to remove settleable material. Sedimentation of sewage is a partial or preliminary treatment used to remove the gross suspended matter. Effective removal of settleable material is dependent upon time of retention and maintenance of uniformly low velocities throughout the entire cross section of the tank. Tanks should have a length of three to five times their width, and a depth of from six to ten feet. Inlet baffles or multiple inlets are required in tanks over 8 ft. wide to promote uniform flow over the tank cross section. The effluent is withdrawn over an outlet weir after passing under a grease scum baffle. Solid matter which settles to the bottom contains 92 to 98 percent moisture and is known as sludge. Sludge will undergo gradual decomposition due to bacterial action and will finally turn black in color and become inoffensive. During decomposition methane and other gases are produced and the sludge concentrates into about half its original volume.

(b) If settling tanks are equipped with mechanical bottom scrappers, the sludge is removed daily and can be digested in "separate" sludge digestion tanks. Mechanically cleaned settling tanks in large sewage plants usually provide about 2 1/2 hours' detention based on 24 hour average rate of flow, or 2 hours' detention at 16 hour average rate of sewage flow. Since mechanical equipment is difficult to obtain at advanced bases, tanks in which the settling and digestion processes are combined must be used. Septic tanks and Imhoff tanks are examples of the latter type.

(c) Septic tank. The septic tank (fig. 7-4) is a plain settling tank in which the sludge is permitted to accumulate and digest for a relatively long period. It is not an efficient device because digesting solids are raised by gas bubbles and pass out with the effluent. During rapid gasification, the effluent may contain more suspended matter than the influent. Ordinarily not more than 50 percent of the suspended matter and 25 percent of the biochemical oxygen demand are removed in a septic tank. The effluent is but slightly less contaminated with bacteria than the raw sewage. Septic tanks should provide 24 hours' retention for the smallest tank to 12 hours' retention for the largest tanks plus an allowance of 25 percent excess capacity for sludge storage. They should not be used for populations greater than 500. Typical tank dimensions are given in table 7-1.

Septic tanks are used to reduce the rate of clogging of soakage pits, sand filters and subsurface tile disposal fields, or to prevent the formation of sludge banks in small streams or bays. They

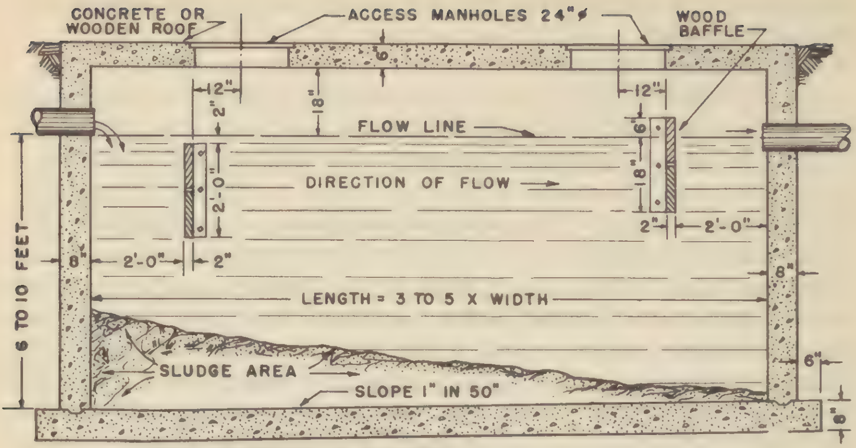

Figure 7-4.--Septic tank

are useful for preliminary treatment of sewage but should never be considered as accomplishing alone a degree of purification that has much public health significance.

Table 7-1.--TYPICAL SEPTIC TANK DIMENSIONS

Basis of design: Settling period, 12 hours for average flow; sewage, 50 gallons per capita daily; sludge storage, 3 cubic feet per capita

Persons served	Width, feet	Length, feet	Depth,* feet	Volume cubic feet
100	6	18	6.0	630
200	8	24	6.6	1,260
500	10	36	8.8	3,150

*Exclusive of freeboard.

(d) Imhoff tank. This is a two-story tank originated by Karl Imhoff but no longer restricted by patents. (See fig. 7-5). Solids settling in the upper central compartment pass through slots to the lower part of the tank. The advantage in this arrangement is that settled solids are not returned to the flow by the gasification process. The settling or flow-through compartment should provide 2 1/2 hour detention period based on average 24-hour rate of flow or 2 hours' detention based on the 16 hour rate of flow, whichever is largest. The sludge compartment should have a volume equal to 3 cu. ft. per person served. Sludge volume is computed from a plane 18 inches below the slots. Gas wells should comprise at least 1/5 of the horizontal area of the tank, but may not be reduced to less than two feet in width. Results

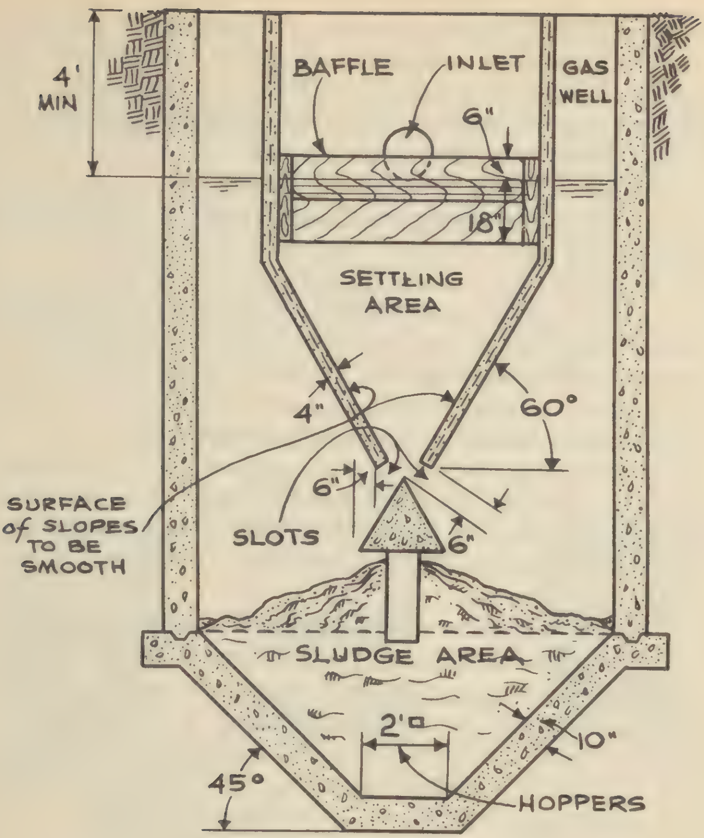

Figure 7-5.--Imhoff tank

to be expected from the Imhoff tank are 40 to 70 percent removal of suspended matter and from 25 to 40 percent removal of biochemical oxygen demand. Table 7-2 gives typical tank dimensions.

Table 7-2.--TYPICAL IMHOFF TANK DIMENSIONS

Basis of design: Settling period, 3 hours for average flow; sewage, 50 gallons per capita daily; sludge storage, 3 cubic feet per capita

Persons served	Width of settling compartment	Width of gas wells	Length	Depth,* settling compartment	Depth below slots	Volume, cubic feet	
						Settling	Sludge
	Feet	Feet	Feet	Feet	Feet		
250------	4	2.0	12	6.0	11.5	209	750
500------	6	2.0	18	7.5	12.8	418	1,500
1,000----	8	2.0	24	9.0	15.6	836	3,900

*Exclusive of free board.

(e) Operation of Settling Tanks. Settling tanks must be given proper care if they are to function properly. Excessive amounts of grease should not be permitted to enter, and rainwater, surface drainage and liquid wastes which do not require treatment should be excluded from the sewerage system. Tanks should be inspected occasionally to check their operation and to determine depth of accumulated sludge and scum. When scum in the gas vent of an Imhoff tank reaches a depth of about 8 inches it should be broken up or removed and disposed of by burial. Sludge should be removed at least annually, preferably in the spring. Since the sludge from combined settling and digestion tanks may contain disease-producing bacteria, disposal should be by burial, dumping at sea, or fill, in an isolated area. Drying on sand beds usually precedes disposal by one of the above methods. The effluents from the tanks discussed here contain large numbers of bacteria, so must be disposed of by dilution in a large body of water or by drainage into a disposal field or seepage pit, or must be given additional treatment.

18. Absorption.

(a) Where the volume of liquid waste is small and the soil is sufficiently pervious, it may be possible to dispose of liquid wastes by absorption in the soil. Soakage pits and trenches described in Section 2 for use in disposing of urine may be used for disposal of water from showers, lavatories, laundry and galley. The volume of liquid waste and the absorptive character of the soil determine the size of pit or trench required. A small test pit will furnish useful information on absorptive capacity of the soil (See paragraph (d)). Subsurface tile fields or cesspools may also be used. These methods are not suitable if the water table is close to the ground surface for considerable periods during the year. Liquid waste containing an appreciable amount of suspended matter should not be disposed of into the soil until it has been given settling treatment.

(b) Subsurface disposal. With this method, waste liquid is conducted into the upper layers of the soil through a system of open joint tile or concrete pipe. (See fig. 7-6). Since continued satisfactory operation depends on bacterial decomposition of organic matter, subsurface tile systems should not be more than two feet below the surface. At greater depths bacterial action is very slight. Main distributing or manifold sewers are laid with tight joints on a grade that will convey the sewage at a velocity of two feet per second. Usually 6-inch tile is used and laid on about a one percent slope. Laterals of 4 or 6 inch drain pipe are laid on about a one-half percent slope with open joints, 1/8 to 1/4 inch wide. The upper circumference of the joints are covered with strips of burlap or tar paper. Laterals are laid in

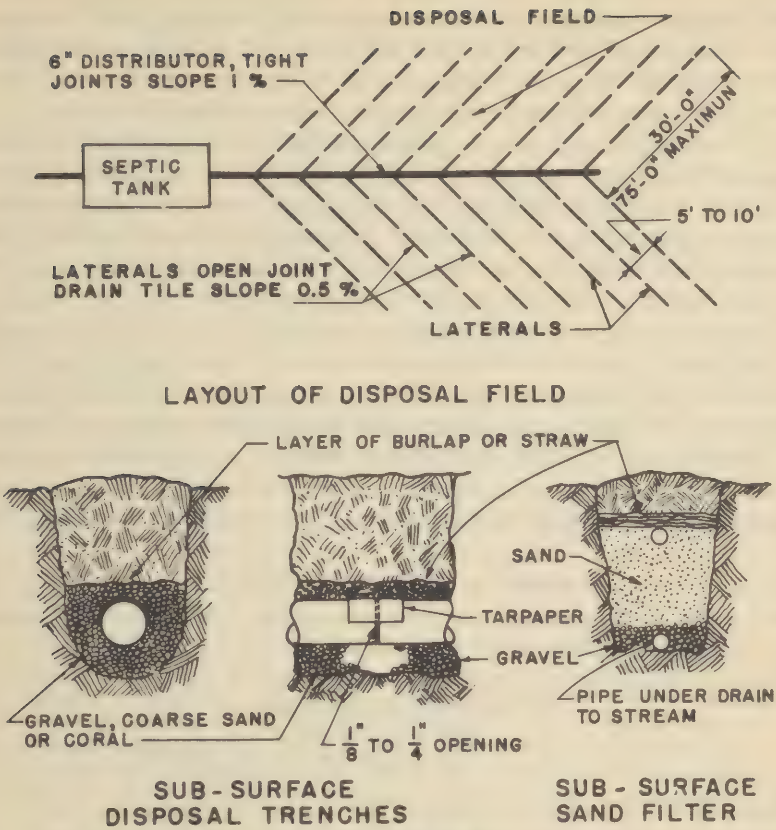

Figure 7-6.--Subsurface disposal system

trenches from 1 to 3 feet wide and spaced 5 to 10 feet apart depending on the porosity of the soil (see paragraph (d)), and from 1 to 2 feet deep, depending on surface contour and depth of the soil. Laterals should be less than 100 feet in length. The tile is placed near the bottom of a bed of broken stone, gravel, or coral about one foot deep and the full width of the trench. The bed of stone is covered with straw, leaves or burlap and the trench backfilled. The laterals may be connected to the main distributor by "Y" fittings. It is good practice to divide the disposal field into two sections so that each section can be rested at regular intervals of time.

(c) Seepage pits or cesspools. - A seepage pit is a covered pit with open joint lining through which waste liquid may seep or leach into the surrounding porous soil. These pits may be used for disposal of liquid waste when the absorptive capacity of the soil is adequate. The pit is usually dug 5 feet or more in diameter and 6 to 10 feet deep. Sufficient wall area should be

provided to permit liquid waste to leach into the soil without overflowing. The pit should be lined with stones, brick or concrete blocks laid dry up to the elevation of the inlet. Above the inlet the joints should be sealed with cement mortar. The distance between seepage pits should be more than 20 feet.

(d) Absorption rates. - The absorptive capacity of soil is estimated by digging test holes, filling them with water, and observing the time required for the water level to drop a given amount. The bottom of the test hole should be at the level of the absorptive area to be employed. If the test holes are made one foot square and filled with six inches of water, the absorption capacity may be estimated from table 7-3. Since dry soil will ordinarily absorb water more quickly than moist soil, the test should be continued long enough to saturate the soil around the test pit. If there is a protracted wet season during each year the tests should be made during this season or allowances made for conditions during the rainy season. Absorption should not be employed in soils of less capacity than the lowest in table 7-3.

Table 7-3.--ABSORPTION RATES

Time for water in test hole to fall 1 inch	Subsurface disposal trench, estimated absorption capacity per sq. ft. of trench bottom	Seepage pit, estimated absorption capacity per sq. ft. of percolating area
1 minute	4.0 gal. per day	5.3 gal per day.
2 minutes	3.2 gal per day	4.3 gal. per day.
5 minutes	2.4 gal. per day	3.2 gal. per day.
10 minutes	1.7 gal. per day	2.3 gal. per day.
30 minutes	0.8 gal. per day	1.1 gal. per day.
60 minutes	0.6 gal. per day	0.9 gal. per day.

19. Subsurface Sand Filters. - When absorption is impossible because of tight impervious soils or a high water table, a subsurface sand filter (fig. 7-6) can be used for disposal of liquid waste. An underdrain is placed in a trench or series of trenches and covered with a layer of gravel or crushed stone. Upon this is placed 12 to 18 inches of coarse sand. A second line of pipe is placed on the sand and then covered with a layer of burlap or straw and the balance of the trench backfilled. The sand layer between the two lines of pipe serves as a filter medium. Liquid waste is applied through the upper system of pipes and the clear drainage is removed by the lower system and conveyed to a drainage channel.

20. Evaporation Beds. - Evaporation beds may be used where the soil is impervious and the climate is hot and very dry. These beds are made by scraping off sufficient top soil to level the area and then constructing an earthen dike 10 to 15 inches high. The leveled surface is then corrugated by raking the bed into a series of ridges. For kitchen waste, three square feet per person should be allowed. Two square feet per person is sufficient to care for bath waste. Beds should be arranged so that waste will be directed to all parts, and a sufficient number of beds should be provided so that some may be out of service for drying and respading. Kitchen wastes must pass through a grease trap before running onto the evaporation bed.

21. Dilution. -

(a) Disposal by dilution, i.e., the discharge of raw or treated waste liquid, into a body of natural water, is the only practical method of disposing of large quantities of sewage. Dissolved oxygen in the diluting water is utilized through the acitivites of bacteria to stabilize organic substance in the waste liquid. If the receiving stream or body of water is overloaded with organic matter, all the available oxygen will be consumed, in which case fresh water life will disappear and the water will become septic and mal odorous. The following ratios of waste liquid to fresh water will insure a safe concentration of dissolved oxygen in the stream, lake or other receiving body:

1 part raw sewage mixed with 100 parts of fresh water

1 part settled sewage mixed with 70 parts of fresh water

1 part filtered sewage mixed with 10 parts of fresh water

(b) Sewage should not be discharged without treatment when there are water intakes, bathing places or shellfish beds in the vicinity of the outfall. When health protection is involved because of the presence of such facilities, complete treatment of waste liquids followed by disinfection with chlorine may be required.

(c) The degree of treatment and the efficiency of a sewage plant is expressed in terms of suspended solids removal, removal of biochemical oxygen demand and the removal of bacteria. Suspended solids settle in the receiving stream, lake or bay and form sludge banks which create obnxious conditions as they undergo anaerobic decomposition. Biochemical oxygen demand (B.O.D.), which is determined by measuring oxygen consumption in samples of sewage effluent or dilutions thereof incubated for 5 days at 20°C, as a measure of the oxygen which must be supplied to support aerobic stabilization of the organic matter in a sewage effluent.

(d) Proper dispersion of waste liquids in the receiving stream is essential. If discharged to a river, the outlet should be placed

so that the current will cause rapid dispersion. If a lake or the ocean is the point of discharge, the outfall sewer should extend to deep water at a point where prevailing currents will not bring polluted water back to the shore.

22. Secondary or Complete Treatment Processes.

(a) Subsurface tile disposal fields and seepage pits described above are simple secondary treatment devices suitable only for the disposal of relatively small volumes of sewage under favorable conditions of soil, topography and climate. When secondary treatment, i.e., treatment in addition to sedimentation, must be given the sewage from more than a few hundred persons, one of the municipal type biological processes should be used and the treated sewage then disposed of by dilution. Three processes are important: (1) the trickling filter process, (2) the activated sludge process, and (3) sand filtration. The many variations both in the design and the operation of equipment utilizing one or the other of these processes can be appreciated only by study of the literature dealing with sewage treatment. All three processes are methods of concentrating in tanks or filters the natural aerobic biological processes which operate to purify and destroy waste material in streams and lakes. Their purpose is to reduce the pollution load imposed on the natural bodies of water into which sewage is discharged.

(b) Trickling filters are beds of coarse stone 6 to 10 feet deep over which sewage is intermittently applied through spray nozzles or rotating distributor arms. As the sewage trickles down over the zoogleic film growing on the stones, organic matter is removed. The accumulated organic slime normally breaks loose and is discharged from the bed twice annually. During this unloading period the filter effluent is highly charged with suspended solids which are removed in secondary settling tanks provided for the purpose. Standard trickling filters are dosed at rates of two to four million gallons per acre per day. High rate trickling filters that treat fifteen to thirty million gallons per acre of filter per day have been developed in recent years. These filters, which involve a variety of patented schemes for recirculating effluent through the filter, do not give as high a degree of treatment as the standard rate filter. The standard rate trickling filter is the simplest and most reliable of all devices for the secondary treatment of sewage. The over-all efficiency of sewage plants having low rate trickling filters is 75 to 95 percent removal of biochemical oxygen demand, 70 to 90 percent removal of suspended solids and 90 to 95 percent removal of bacteria. Chlorination removes additional biochemical oxygen demand and kills many of the remaining bacteria.

(c) The activated sludge process involves blowing of air into the sewage or otherwise aerating it for a period of six to eight hours in the presence of biologically active sludge. The sludge or flocculant zooglea is settled in final settling tanks and pumped back into the sewage entering the aeration tank. The sludge performs the same function as the zoogleic film on the rocks of a trickling filter; that is, the organisms contained feed on the organic matter in the sewage. Since the sludge grows during aeration, an excess above the requirements for the process appears in the final tanks. This excess sludge is usually returned to the sewage ahead of the primary clarifiers and is removed in the preliminary sedimentation tank to be disposed of along with other primary sludge. The construction cost or first cost of an activated sludge plant is generally less than that of a trickling filter plant of equal capacity. The cost of operating an activated sludge plant is, however, much higher. The process requires expert control and at best the results are likely to be erratic. The crystal clear effluent produced when this process is operating well often leads to a favorable impression of the process that can not be supported by its average performance. When operating properly, an activated sludge plant will produce a somewhat better effluent than a low rate trickling filter plant.

(d) The intermittent sand filter is an underdrained sand bed onto which one hundred thousand gallons or less of raw sewage up to a million gallons, of completely treated sewage per acre per day is applied in one to four intermittent doses. The sewage is flooded onto the bed as rapidly as possible. Time is then allowed for the liquids to filter through the bed and for the bed to aerate and rest before the next dose is applied. Three or more filter beds are usually required to attain the proper schedule of rotation. The sand surface must be raked or harrowed as necessary to maintain reasonably rapid filter rates. When raking is no longer effective, the upper layer of the sand must be removed. Intermittent sand filters produce a high degree of treatment. They may be improvised without difficulty using only tile or concrete sewer pipe if natural sand beds are conveniently located. The large area required and difficulties with odors are the principle disadvantages of this method of treatment.

(e) Large sewage treatment plants have screens for removing coarse solids and have grit chambers to remove sand and heavy suspended matter that might clog pipes or cause excessive wear of pumps and other equipment.

23. Chlorination of Sewage.

(a) None of the so-called complete treatment processes will eliminate all the pathogenic organisms from sewage. It may,

therefore, be necessary to disinfect the treated effluent in order to protect bathing beaches, shellfish beds, or water supplies if these are near the point of discharge. Disinfection of sewage should not be employed unless required by a Department of Public Health or needed to protect naval personnel who have occasion to swim or work in the water near the outfall. Chlorine or chlorine compounds are used to disinfect sewage. Chlorination of the partially, or completely treated sewage, may also be used during hot dry weather to delay or inhibit decomposition in the receiving stream until the sewage has been widely dispersed. Chlorine is sometimes used in treatment plants to reduce odors or control the behavior of biological devices.

(b) Not less than 0.5 part per million of residual chlorine after a 15 minute contact period is needed for reasonably effective disinfection. Doses required may be expected to be in the following ranges: septic tank effluents 10 to 25 ppm, Imhoff tank effluents 5 to 20 ppm and trickling filter effluents 3 to 15 ppm. Since the character of any sewage effluent is subject to wide variations, chlorine doses must be frequently adjusted if uniform results are to be obtained.

24. Sludge Disposal. - Sludge from the sedimentation tanks of a sewage plant may be disposed of in a variety of ways. In plants having mechanically cleaned settling tanks the sludge is usually subject to anaerobic digestion in separate heated tanks prior to its ultimate disposal. During digestion methane gas is produced and the organic solids are changed into humus-like material. Sludge gas is similar to natural gas and may be used to heat digestion tanks, to operate gas engines or for general heating purposes. Sludge gas has a fuel value of around 650 B.T.U. per cubic foot and is produced at a rate of about one cubic foot per day per person contributing sewage. The digested sludge is dried on sand beds or on vacuum filters and is then dumped, used as a low grade fertilizer or burned. Undigested sludge may be buried or barged to sea.

25. Salvage of Sewage Products.

(a) Clarified effluent from secondary treatment processes can be used to irrigate lawns and landscaping but care should be exercised with waters of high chloride content since grass and shrubs may be damaged by its use.

(b) Sewage solids to be used as fertilizer must be digested and dried; or if undigested, must be kiln-dried at temperatures which will destroy pathogenic organisms. Only sludge with a low grease content should be used as fertilizers or as soil conditioning agents. Ordinary digestion does not guarantee absence of all pathogenic organisms; consequently sludge should

not be applied indiscriminately to areas where personnel train or exercise.

Section IV.--REFUSE DISPOSAL

26. Refuse Includes Garbage and Rubbish. Garbage is waste food or waste material incidental to the preparation of food. Waste material such as tin cans, glass, paper, boxes, ashes, sweepings, etc. is classed as rubbish and may be combustible or non-combustible. Refuse produced at advance bases amounts to 1.5 to 2.5 pounds per day per person, one third of which is garbage. If garbage is not handled and disposed of in a sanitary manner it will create a nuisance and provide food or a breeding place for rats, for flies or other insects which contribute to the spread of disease. Combustible rubbish can usually be disposed of by incineration. Non-combustible rubbish may be dumped if precautions are taken to prevent water accumulations in which mosquitoes will breed, but disposal by sanitary fill is preferred. Garbage may be disposed of by burial, by dumping at sea, or by sale or gift. Mixed garbage and combustible rubbish may be incinerated if climate permits. Mixed garbage and non-combustible refuse can bedisposed of by dumping at sea or by the sanitary fill method.

27. Refuse Handling.

(a) Collection. In the military services refuse is sorted into garbage, combustible rubbish, and non-combustible rubbish by the use of separate receptacles so that each type of refuse may be disposed of by the most suitable method. Garbage should be stored for collection in standard galvanized iron cans with tight fitting lids. Rubbish is placed in similar cans or boxes conveniently located to encourage their use. Tin cans must be properly disposed of to eliminate possible sources of insect breeding. Garbage receptacles should be kept covered and should be collected regularly and frequently for transportation to the point of ultimate disposal or to a central transfer station. In order to minimize spilling during transportation the cans should not be filled above four inches from the top.

(b) Garbage stand and transfer stations.

(1) In semi-permanent camps garbage stands should be installed adjacent to the galleys. The best garbage stand consists of a concrete block enclosure filled with stone and earth and capped with a concrete slab. It should have a concrete apron around the base. The platform should be at truck floor level to facilitate transfer of cans from stand to truck. If concrete is not available stands may be made of wood. The boards forming the platform should be laid at

least one inch apart to prevent accumulation of organic matter in the cracks. Wooden stands should be moveable in order to facilitate cleaning and oiling the ground beneath them. It is better to keep the stand clean and the cans covered with fly tight lids than to attempt screening. Inclosed and screened garbage stands are difficult to keep clean, but if the screens are kept painted with DDT solution, they make excellent fly-killers.

(2) Where garbage and rubbish are picked up by the same truck and the cans must be sorted before being sent to seperate disposal points a transfer station is required. This station should consist of a truck-height platform similar to the garbage stand but with an area of 150 sq. ft. per 1,000 men.

(3) Receptacles used for garbage should be cleaned at frequent intervals with hot water, soap, and stiff scrubbing brush. When steam is available this should be employed to sterilize the cans. Provision should be made for straightening cans and lids. The platform should be scrubbed daily with stiff scrubbing brush and hot soapy water, and the ground surrounding the stand should be sprayed or dusted with DDT as needed.

28. Burial.

(a) Trench or pit method. At small outlying activities and on the march or in bivouac, garbage may be buried in trenches or pits which are three or more feet in depth. Each day's accumulation of garbage must be thoroughly sprayed with oil or given one of the other fly control treatments recommended for latrine pits, paragraph 11. When the trench or pit is filled to within 24 inches of the surface, the garbage is given a final thorough spraying and covered with 24 inches of well packed dirt. Non-combustible wastes such as broken glassware, sweepings, ashes and flattened tin cans can be disposed of on the surface without nuisance. At permanent or semi-permanent camps of considerable size, mixed garbage and rubbish may be disposed of by the sanitary landfill method.

(b) Sanitary landfill method.

(1) Low areas such as ravines, swamps and abandoned borrow pits are suitable sites for landfills, provided fill operations do not obstruct natural drainage courses. Earth, preferably sandy soil, should be available for cover material. Clay soil is not recommended as it does not provide proper sealing because of shrinkage.

(2) Operation consists of dumping a mixture of garbage and rubbish in a layer approximately six feet thick, com-

pacting it with heavy mechanical equipment, and covering it promptly with a layer of earth to exclude rodents and other vermin and to prevent the escape of odor or the outbreak of fire (fig. 7-7). In the method illustrated, a trench about 30 inches deep and 8 to 24 feet wide is excavated to provide earth for covering the refuse already dumped. This trench is then filled with a 6 foot layer of refuse which is compacted by heavy mechanical equipment and promptly covered with two feet of earth from the next trench. At bases of less than 20,000 men, a "bull clam" shovel attached to a tractor may be used for digging the trench, compacting the fill and applying the earth seal. In larger camps, a power shovel or drag line may be used. Thorough compaction of the fill material assists in obtaining uniform settlement and reduces

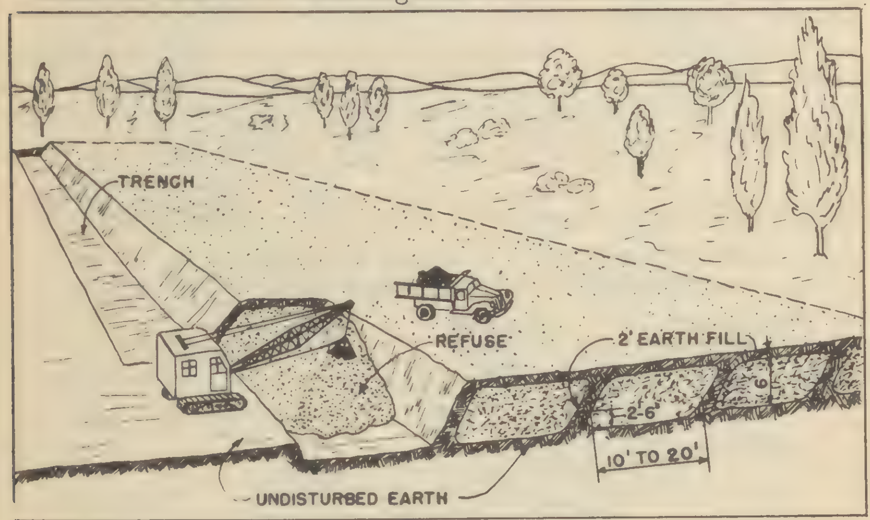

Figure 7-7.--Sanitary landfill

the amount of cover required. Although rats will ordinarily not burrow more than 12 inches, a cover of 24 inches in depth is necessary on the surface and face of fills to compensate for uneven settlement. If flies have an opportunity to lay eggs in the garbage before it is covered with earth, the dumped material must be thoroughly sprayed or dusted with DDT or sodium arsenite solution before the earth cover is applied. An area of 0.75 to 1.5 acres will be required each year for each 10,000 men.

(3) Most important factors for the success of this method are initial compaction of the refuse and cover and maintenance of the completed fill. Maintenance involves trimming and filling cracks and eroded places. Inspection for the presence of burrowing animals should be carried out as needed.

29. Dumping at Sea. - Disposal of garbage and rubbish by dumping at sea is sanitary and convenient. Often a study of winds and currents around an island or base will disclose a location where wastes can be dumped at the shore or on reefs, and will be carried completely and permanently away from the area. The dumping schedule frequently has to be timed to the tide for shore disposal to be successful. If disposal close off shore is not satisfactory, the wastes may be barged 5 or 10 miles out to sea to a point where the wind or currents will not return them to the beaches. A barge must be assigned specifically for this purpose and a transfer station must be developed at the docks. Self dumping barges improvised from pontoons facilitate discharge of the garbage at sea. Both the barges and the loading station at the dock must be maintained in a sanitary condition.

30. Incineration.

(a) Incineration may be used to dispose of a variety of materials with more or less success depending on the character of the waste, the type of incinerator, the climate, and the quality of operation and supervision. Combustible rubbish kept dry can

LONGITUDINAL SECTION HILLSIDE INCINERATOR

with evaperator pit — useful in disposing of semiliquid waste in impermeable soil

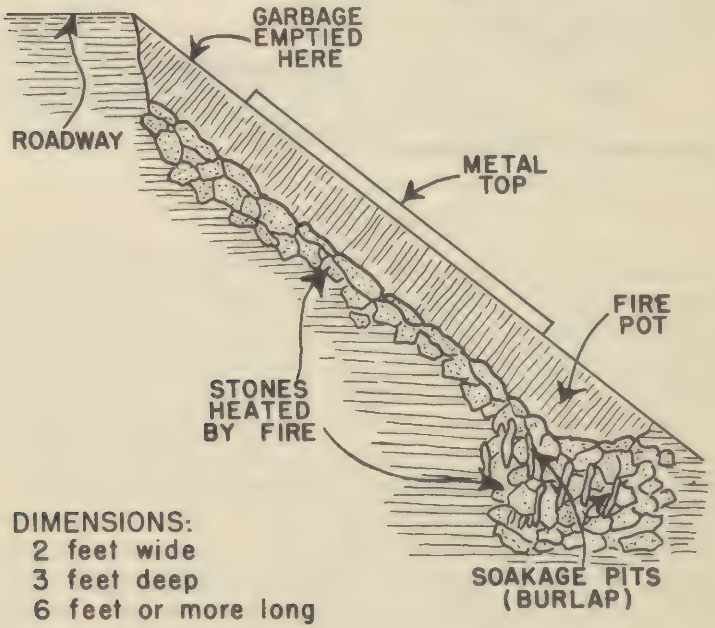

Figure 7-8.--Hillside incinerator

be burned in the open or in the simplest of incinerators. Garbage or wastes from pail latrines can be burned satisfactorily only in enclosed or semi-enclosed incinerators provided with drying planes or platforms. Rubbish or other fuel must be used to fire an incinerator in which garbage is burned and continuous and careful charging and stoking is required. During seasons of heavy rainfall in the Tropics incineration frequently fails. The characteristics of incinerators are as follows:

Closed type.

1. More quickly started.
2. Not so liable to be put out by rain.
3. Not so productive of bad odors.
4. Produces more heat.
5. Practical in permanent camps.

Open type.

1. More easily constructed.
2. Requires less material for construction.
3. Completely adequate for dry combustible rubbish.
4. Practical in semi-permanent camps.

(b) Closed type incinerators.

(1) The hillside and inclined plane incinerators are the most practical types for advanced base use. In large permanent shore-based activities a municipal type incinerator may sometimes be practical. The latter are complicated in design and would be selected only after consultation with engineers and equipment firms experienced in the construction of large incineration plants.

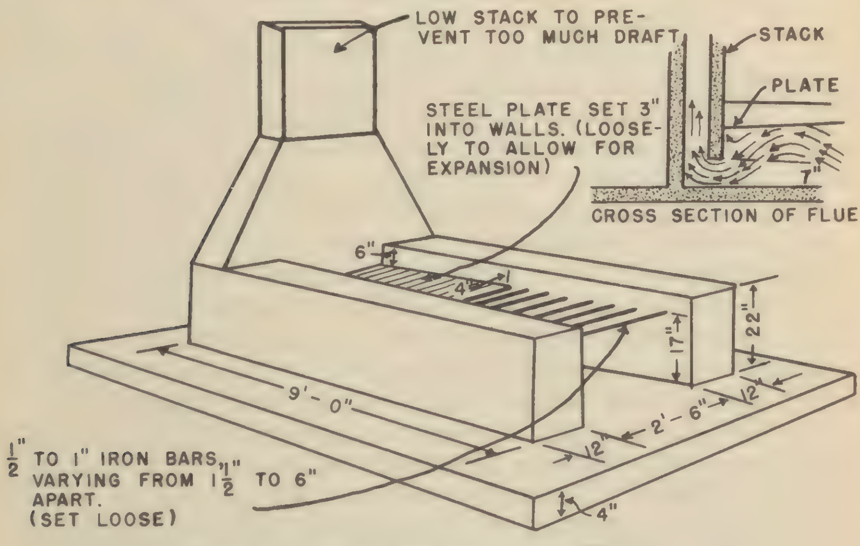

Figure 7-9.--Plate and grate incinerator

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(2) Hillside incinerator.- The "hillside" method of incineration (fig. 7-10) first devised by Rear Admiral W. L. Mann, (MC), USN, and described in the journal of the American Medical Association, April 6, 1918, has proved simple and satisfactory. A trench about 2 feet wide, 3 feet deep and 6 feet or more long is excavated in a steep hillside or bank. At the foot of this trench a soakage pit is excavated and the bottom of trench and the soakage pit are filled with stone. The trench is covered with sheets of corrugated iron or other metal to assist in creating a draft when the wood or rubbish fire is built over the soakage pit. Garbage or other waste is dumped at the top of the trench and is stoked gradually down the rock bottom of the trench. Liquids drain down into the rocks in the trench and pit where they soak into the ground or are evaporated. The hot rocks and combustible gases dry the garbage as it progresses downward into the fire. This mode of disposal has the following advantages:

(a) Simplicity. One man can effectively and efficiently dispose of the excremental and garbage refuse of 5,000 persons.

(b) Availability. Almost every terrain contains a sloping hillside or a small embankment that may be utilized.

(c) It requires a minimum amount of fuel.

(d) A large surface area of liquid is exposed to heat thus facilitating evaporation. The hillside incinerator will prove most useful where there is a large mass of wet garbage to dispose of and where night soil must be burned.

(3) Inclined plane incinerator.- This incinerator is a refinement of the hillside type in which the incline drying plane is supported by walls. The incinerator may, therefore, be constructed on level ground. The walls and the floor under the grate are built of concrete, brick or rubble masonry. The inclined charging plane is either sheet steel, not lighter than No. 16 gage, or corrugated iron, or if the space between the walls is backfilled with local material, the charging plane can be paved with stone. The incline is roofed over by pieces of oil drum, mounted in walls 8 inches or more above and parallel to the incline. Each piece of drum consists of one-third of a single drum, cut longitudinally clear through the ends. A fire of rubbish or wood is built upon the grate and, after the incinerator has become hot, the garbage is shoveled or dumped from cans into the opposite or upper end. The action of the hot gases will dry the garbage as it is pushed slowly down the incline. The ends of the oil drum

sections serve as baffles and give rise to swirling of the hot gases, which greatly aids the drying out of the garbage on way to the grate where complete incineration is effected. Numerous varieties of this inclined plane type of incinerator have been improvised and used successfully in the field.

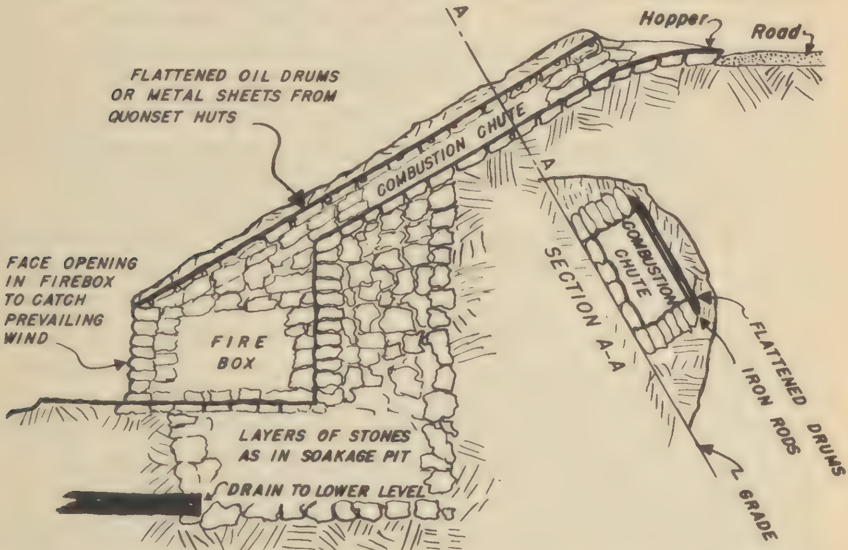

Figure 7-10.--Rock-lined type of hillside incinerator which can use flattened oil drums or metal sheets from Quonset huts for cover.

Opening in fire box faces prevailing wind. This model is best built with the lower 6 feet of the incline as a soakage pit and the bottom of the fire box as a soakage pit. Volcanic rock, not coral rock, should be used.

(c) Open Type Incinerator.

(1) Cross-trench, plate and grate and rock pile incinerators are examples of the open type which are suitable for field use, although the closed type is preferred.

(2) Cross-trench incinerator.- This consists of two intersecting trenches over which is placed a grate and the stack. The trenches are 12 to 18 in. wide, 10 ft. long and 18 in. deep at the grate or stock. The grate can be constructed of steel flats, 2 in. on centers, or may be made of any convenient pipe or metal rods. The stack can be constructed of stone or brick or improvised from an oil drum. During operation the leeward trenches are blocked with pieces of sheet metal to improve draft.

(3) Plate and grate incinerator.- The incinerator shown in Fig. 7-9 is large enough to dispose of the waste of 200 men. Wet garbage is deposited on the plate near the stack where it dries slowly. Portions which have dried sufficiently

are raked over the iron rods where they are burned and fall into the firebox. This incinerator is fired with rubbish and scrap wood.

(d) Operation of Incinerators. - Attendants should be trained to add garbage slowly to incinerators so that it will not put out the fire, to use care in dumping garbage receptacles so as not to injure the incinerator or the receptacles and to clean the firebox at frequent enough entervals to prevent burning the grates. The area surrounding the incinerator should be kept clean at all times. Ashes used as fill may have to be covered with earth to prevent their being spread about the camp by the wind.

31. Sale or Gift. - Garbage is often disposed of to civilians for hog food. This disposal may lead to insanitary conditions about a camp through spilling in transfer from garbage can to other containers, leakage of containers, failure of collection, or unsatisfactory cleaning of cans. When thorough cooperation with the contractor can be maintained so as to insure cleanliness in the procedure, there is no objection to this method of disposal. However, the hog farm should be far enough removed from the camp that odors and flies will not be a nuisance. When garbage is used as food for hogs the edible garbage must be separated from the non-edible portion. The edible garbage from a 500 man galley will feed 10 to 15 hogs. It is recommended that garbage be cooked before using it to feed the hogs in order to reduce trichinosis. Garbage-fed hogs should be immunized against hog cholera.

Chapter 8

Essentials of Field Sanitation

Section I.--INTRODUCTION

1. Sanitation, in the broadest meaning of the word, may be defined as the successful adjustment of the environment to the body so that disease is prevented and health is promoted. More specifically, sanitation means the practical application of the laws and principles of hygiene to the varied conditions of life under which men live and work. The laws of hygiene are everywhere the same but the practical application of these laws, i.e., sanitation, varies according to circumstances. For instance, it is a hygienic law of universal application that a safe and dependable water supply is one of the necessities of life. It is the responsibility of the Navy Medical Department to make certain that barriers to the spread of water-borne diseases are adequate and to prevent the creation of health hazards due to faulty design and operation of water supply systems. The medical officer's responsibilities are the same under a wide range of conditions, whether it be to provide an individual in the field with a safe canteen water supply, or to advise on the installation and operation of a water supply system for a large shore establishment. In the same manner, and under a variety of circumstances, the medical officer must accept and discharge his responsibilities with regard to waste disposal, insect and rodent control, messing sanitation, ventilation, illumination, housing, and a host of other subjects that have a direct relationship to the health and well being of the command.

2. In no situation will the medical officer's resourcefulness, ingenuity, and ability be put to a greater test than in planning for and executing sanitary control under field conditions, where the problems are those of an invasion force operating in the Tropics. This chapter has been prepared to assist

the medical officer in meeting sanitation problems under combat conditions and at the same time to serve as a general guide in routine sanitation training, organization, and maintenance of advanced bases and permanent establishments.

Section II.--PURPOSE, RESPONSIBILITY, AND ORGANIZATION

3. Purpose of Sanitation

(a) The fundamental purpose of field sanitation is the prevention of disease, i. e., preventive medicine. The importance of the application of well-established practical measures in field sanitation cannot be overemphasized if the Medical Department is "to keep as many men at as many guns as many days as possible". The medical officer who practices good preventive medicine is contributing as much to his country as the surgeon who dramatically saves lives.

(b) The Manual of the Medical Department gives a brief outline of the duties of the medical officer and his responsibilities in field sanitation. Since all officers should be thoroughly familiar with this section, parts are quoted here:

> Preparation for Field Service.--35A20.1. After becoming familiar with all health and sanitary data available on the area to be occupied, the medical officer shall formulate a plan and the necessary sanitary orders for the practical solution of problems likely to be encountered and present them to the commanding officer for approval and execution. The plan shall provide for:
>
> (1) The indoctrination of all personnel in personal hygiene, sanitation, and the special protective measures to be used.
>
> (2) The assignment of an adequate complement of nonmedical personnel (approximately 2 percent of the command) to sanitary duties such as maintenance and care of latrines and urinals, fly control, mosquito control, rodent control, and garbage and waste disposal. In combat areas, additional personnel must be assigned for the handling and burial of the dead.
>
> (3) The thorough indoctrination of the nonmedical personnel in their sanitary duties for efficient performance with a minimum of supervision.
>
> (4) The assignment and enforcement of priorities for the acquisition of materials and supplies and the early construction of sanitary appliances in the field.
>
> (5) The selection and physical examination of food handlers, and their indoctrination in personal hygiene, sanitation in the preparation of food, and the care of utensils and mess gear.
>
> (6) The approval of the medical officer before galleys are placed in operation.
>
> 35A20.2 Planning, indoctrination, and training shall be completed in the training camp or staging area to provide an efficient, well trained sanitary organization upon landing.

4. Responsibility for Sanitation.

(a) Commanding officers of all grades are responsible for sanitation and for the execution and enforcement of sanitary orders and regulations within their organizations and the boundaries of areas occupied by them. Commanding officers should request the Medical Department to investigate and advise upon sanitary conditions, and should act upon all recommendations and suggestions from the Medical Department.

(b) The Medical Department is responsible for investigating sanitary conditions and installations and for submitting recommendations and suggestions for the correction of any existing or potential sanitary hazard. The Medical Department will specifically investigate and advise in relation to the following:

(1) Selection of camp site.
(2) The source and purification of water supply.
(3) Treatment and disposal of human excreta, garbage, and trash.
(4) Messing sanitation.
(5) Control of insects and rodents.
(6) Maintenance of sanitary facilities.

(c) The Medical Department is further charged with the responsibility of the following:

(1) Execution of all measures for conferring immunity from disease on military personnel and animals.
(2) Training in personal hygiene and sanitation.
(3) Supervision, training, and indoctrination of sanitary units (G-22-A), and sanitary squads from Construction Battalions and Marine Corps battalions.
(4) Indoctrination of all personnel in measures for control of malaria and other exotic diseases.
(5) Periodic examinations of all personnel connected with food handling. These examinations should include, where indicated, stool cultures for enteric pathogens, stool examinations for intestinal parasites, and chest x-ray.
(6) Periodic sanitary inspections of the entire camp and all its activities.
(7) Preparation of a sanitation section for the medical standard operating procedure, of sanitation bills and directives, and of the official reports to the Bureau.
(8) Assist with the preparation of plans and the development of a properly trained and equipped organization for the efficient burial of our own and the enemy dead.

(d) In some organizations the Medical Department is augmented by officer and enlisted personnel with specific technical training in epidemiology, sanitation, and mosquito and pest control. When such personnel are available they should be employed in these fields and should not be required to perform duties which interfere with their primary mission.

5. Organization.

(a) Medical Officers.--The senior medical officer of a command or station is charged, under the commanding officer, with the general supervision of the medical department. Medical officers, as technical advisors of their commanding officers, are responsible for pointing out insanitary conditions and making proper recommendations for their correction, but the direct responsibility rests with the commanding officer.

(b) Sanitation Officer.--The senior medical officer should appoint a member of his department as sanitation officer. In an established camp or in a small organization, this duty may be in addition to the regular duties of the officer appointed. In larger organizations such as a Marine Division, field sanitation warrants a full-time sanitation officer. If the medical department has attached a malaria and epidemic control component (G-19), the sanitation officer should maintain close liaison with the officer-in-charge of this component, (i.e., the malaria and epidemic control officer).

(c) Area Sanitation.--In any forward area or theatre of operation, there should be attached to the island or area commanding officer's staff an island or area sanitation officer. This officer may, if circumstances permit, have attached to his staff personnel trained in epidemiology, sanitation, malaria, and pest=control duties. It will be his responsibility to correlate and to assist the various medical officers in charge of the lower echelons with their sanitation programs. He should also assist with problems of supply, personnel (labor details, etc.), training, and any over=all program for the area such as mosquito, insect. and rodent control projects.

(d) Special Sanitary Components.--The below-named components are specialist groups that have received special courses of instruction to qualify them for their work. They are available for their specialized function only and, with the exception of G-22A, they are not designated in any manner as labor groups.

(1) Malaria Control Component (G-17).--This is a sanitary unit equipped with facilities for locating mosquito breeding places, identifying types of mosquitoes present, making blood surveys for the determination of

malaria infections, and assisting in and recommending measures for malaria control. The personnel complement consists of one specialist officer and five malariology technicians who have received specific technical training in malariology.

(2) Epidemiology Components (G-18). This is a sanitary unit for the epidemiological and laboratory investigation of sources of disease and for the recommendation of measures for the prevention of disease. It is equipped to make epidemic and pre-epidemic surveys, to investigate food, water, and milk supplies, and sewage, garbage, and waste disposal. The personnel complement consists of two medical officers and four epidemiology and sanitation technicians who have received specific technical training in epidemiology.

(3) Malaria and Epidemic Control Component (G-19). This is a sanitary unit equipped for epidemiological and laboratory investigation and the prevention of diseases. It is trained and equipped to supervise the control of insect vectors, of animal reservoirs of disease, of food, water and milk supplies, and of sewage, garbage, and waste disposal. It is equivalent to two G-17 components and one G-18 component combined. One such component is attached to the Headquarters and Service Company, Medical Battalion, of each Marine division as specified in the Marine Corps Table of Organization. The senior medical officer of the component is designated as division malaria and epidemic control officer.

(4) Rodent Control Component (G-22A). This is a sanitary unit equipped to determine the presence, distribution, population, and species of rodents in an area. Personnel are trained to make recommendations for control, to provide material and supervisory personnel to effectuate these recommendations, and to train such additional personnel as may be required in an area in the measures employed to control and eradicate all rodents which may be carriers of disease or which may be destructive to stores and crops. The personnel complement consists of one specialist officer and one technician with specific training in rodent control.

(5) Sanitation Component (G-22A).-- This component is designed to assist the appropriate commander in the discharge of his responsibility for sanitation and disease control measures. It assists G-17, G-18, or G-19 components in conducting sanitation surveys, planning and

supervising the initiation or maintenance of sanitation measures necessary to prevent disease, and directing the efforts of personnel (either military or civilian) made available by the appropriate island, base, or area commander. When such components are attached to a Marine division, they should be attached with the G-19 component and come directly under the jurisdiction of the division malaria and epidemic control officer or the sanitation officer.

Personnel (approximate): No officers and 20 enlisted men, with 1 HMC, total 20.

Material (major items only): (a) Hand tools and equipment; (b) sprayers, dusters and insecticides; (c) transportation equipment; (d) construction materials, lumber, nails, etc.; (e) toolshed, hut 20 by 48 feet.

Weight: Approximately 30 long tons.

Cube: Approximately 110 measurement tons.

(6) Sanitary Section of Construction Battalions.--Construction Battalions have included in their Table of Organization 50 men designated as a sanitation section who have received specific instruction in field sanitation. The section should include such specialists as carpenters, machinists, vehicle drivers, welders, etc. It is designated for the purpose of constructing and maintaining sanitary installations and should be under the direct supervision of the sanitation officer or the malaria and epidemic control officer. The section should not, however, for administrative purposes, billeting, etc., be detached from their respective companies within the Construction Battalion. Prior to movement into a forward area definite provisions must be made for equipment for this section.

(7) Other Personnel.--

(a) The Manual of the Medical Department specifies that approximately 2 percent of the command can be assigned to sanitary duties such as maintenance and care of latrines and urinals, fly control, mosquito control, rodent control, and garbage and waste disposal. It further states that in combat areas, additional personnel must be assigned for the handling and burial of the dead. It will be the responsibility of the Medical Department of ascertain the names, rates, etc., and prepare a rosterof the personnel assigned for this work. The Medical Department will also have to train this group well in advance of the "rediness date" for their Command.

(b) Marine Division Sanitation Squad.--The Table of Organization for the U.S. Marine Corps specifies that each battalion will have a three=man sanitation squad. It is important that each battalion surgeon have this squad under his direct supervision. The battalion surgeon should also be certain that the squad is thoroughly trained in its duties. If the Marine organization has at its disposal a malaria and epidemic control component (G-19), the battalion surgeon should secure the cooperation of the division malaria and epidemic control officer in all matters pertaining to training, duties, equipment, etc., of the sanitation squad.

Section III.--PLANNING

6. Importance.--Well in advance of any combat operations, period of occupation in a foreign zone, etc., the command must formulate a definite plan for field sanitation. The senior medical officer must cooperate closely with the administrative branches of the command, especially with the Intelligence Section. Most of the necessary information for planning will be "Secret" or "Confidential" and it must be handled as such. The senior medical officer should have periodic meetings with his medical officers so that pertinent information is made available to all concerned. Tentative plans should be weighed carefully and all officers should have an equal opportunity to contribute suggestions.

7. Intelligence Data.--Before formulating detailed plans, the following information should be obtained:

(a) Name and geographical location of objective. This must be known in order that standard reference material can be checked for information.

(b) Type of operation. Amphibious, combat or noncombat.

(c) Climate. Mean temperature, average rainfall, relative humidity. This data will determine the type and amount of clothing to be worn, amount of bedding indicated and will also have a direct bearing on the expected incidence of respiratory diseases as well as an indirect bearing on other endemic diseases such as those from insect vectors.

(d) D-day and date of disembarkation. D-day must be checked against the climate for that time of year. The amount of clothing and personal supplies such as repellents, nets, individual medications, and rations that each man should carry ashore will be influenced by climate at the objective.

(e) Estimated time in area. Official estimate on length of

time in the area will determine the amount and type (field or garrison) of sanitation and messing equipment.

(f) Topography. This will have a direct bearing upon expected diseases, health hazards, and insect vectors.

(g) Water. The Medical Department should be informed regarding sources of fresh water so that the necessary equipment for distillation or treatment can be recommended.

(h) Sewage and waste disposal. It must be determined what methods are in use by the local civilian and military personnel and what methods and materials should be used by our force. If the local population utilized "night soil" as fertilizer, massive soil contamination can be expected.

(i) Medical intelligence data. Estimates should be obtained concerning the type and incidence of disease present among civilians, standard of living, culture, social customs and practices, industry, and hospitals and medical facilities. It will be necessary to determine what sanitary supplies will be needed to care for civilians and Prisoners of War.

(j) Entomological intelligence data. Although this information may be scanty, it is important to be acquainted with all actual and potential arthropod vectors present. If disease-carrying and poisonous species are known in advance, plans for control can be simplified and made more effective.

(k) Domestic and wild animals. Since these may act as reservoirs for communicable diseases, information concerning the species and number is important. It is well to know the dangerous mammals and snakes so that troops may be forewarned. Dead animals must be buried or disposed of to prevent fly breeding and disagreeable odors.

(l) Bathing places. Bathing in all fresh and brackish water areas should be prohibited until it has been determined that there is no danger of contracting enteric diseases and others such as schistosomiasis. If bathing is restricted to salt water, then other hazards as sharks, coral reefs, etc., should be investigated. Since lacerations from coral easily become infected, they often develop into incapacitating wounds.

(m) Civilians and prisoners of war. The Civil Affairs authorities are responsible for the care of civilians and prisoners of war. However, in the forward areas and during the early phases of an operation it will be necessary for the activity concerned to provide this care. Sufficient supplies and equipment must be available for this purpose.

(n) Estimate of enemy dead to be buried. The Medical Department should be certain that adequate personnel and

supplies are provided to assure early and efficient burial of the enemy dead (see par. 11). This is important in warm climates where bodies decompose rapidly and support fly breeding.

8. Personnel (see also par 5(d)).--When an operation is planned, the Medical Department must see that personnel are assigned by name for sanitation functions and duties. This responsibility may be delegated to the sanitation officer who should be certain that a sufficient number of men, approximately 2 percent of the command, are assigned sanitation duties and that these men are thoroughly trained and adequately supplied for their mission. Skilled personnel such as carpenters, heavy equipment operators, sign painters, and tinsmiths are valuable men for field sanitation. The carpenters can construct and maintain flyproof latrine boxes, repair flyproof galleys and mess halls and construct mosquitoproof lids for rain barrels, etc. Sign painters can prepare markers for dumps, trash barrels, garbage cans, scullery lines, contaminated and unauthorized water points, wells, and markers to point out the location of latrines and urinals. Tinsmiths can build urinals and assist in flyproofing work. Heavy equipment operators can drive trucks and bulldozers necessary for burial points and dumps, and operate and drive power sprayers. When the command embarks for the objective, the sanitation officer must be responsible for the stowing of the sanitation gear. He should assign specific men to accompany this gear so that it will not become lost in the confusion. He should also formulate plans for disembarkation that will make it possible for him to maintain supervision over his personnel and equipment.

9. Standard Operating Procedure for Medical Department

(a) During preparation for an operation, the Medical Department should submit a detailed plan for all medical functions, including field sanitation, to the commanding officer for his approval and signature. When it has been signed and included in the Standard Operating Procedures for the command it becomes an administrative order requiring strict compliance. The following will serve as a rough guide to the Medical Department for the topics which must be covered in the section on field sanitation. When final plans have been made the Standard Operating Procedures should be written in the form of an administrative order.

10. Guides for preparing Sanitation Standard Operating Procedures.

(a) Phase I - Period of Preparation.

(1) Indoctrination and training (see sec. IV).

(a) All medical officers should thoroughly familiarize themselves with the diseases anticipated and the necessary preventive and control measures.

(b) All officers and men should be indoctrinated in the methods, means, and reasons for utilizing individual protective measures in the prevention of disease. Unit medical officers should be responsible for the indoctrination of all men in their respective units. The malaria and epidemic control officer (if available) or the sanitation officer should supervise the training program. It is advisable to establish a central sanitary exhibit for demonstration of practical methods and devices. Training should be continued through the period spent on board ship in transit to the objective. Posters, lantern slides, and movies should be used as indicated and where available.

(c) Sanitary squads or units should be specifically trained in the duties of sanitation and malaria and epidemic disease control by the malaria and epidemic control officer or the sanitation officer.

(2) Immunization programs will be initiated in accordance with BuMed directives as modified by fleet or force instructions. (See par. 10).

(3) Sanitation supplies.* Lists must be submitted for distribution, on the basis of personnel strength, to individual units, officers, and men. An additional supply should be carried by the Supply or Quartermaster Corps for resupply in the field as the occasion arises.

(4) Special measures deemed necessary after a study of the theater of operations will be supervised by the malaria and epidemic control officer or the sanitation officer. These may include DDT application by airplane, impregnation of clothing and blankets with repellents and insecticides, and treating all tentage, screening, individual bed nets, head nets, and cots with DDT.

(5) Special items to be constructed prior to embarkation shall include prefabricated flyproof latrine boxes and fly traps that can be easily transported and assembled in the field. Although the provision of these items is a function of the quartermaster, the engineers or C.B.'s will construct the desired number when authorized by the

*Experience has shown that close cooperation between the Medical Department and the Supply Corps or Marine Quartermaster is necessary if all supplies are to be available for distribution prior to the readiness date.

quartermaster. Consideration should be given to the advisability of constructing prefabricated flyproof galleys and mess halls.

(6) If the objective is in a malarious area, specific plans must be made for the administration of suppressive therapy, (see 16(e)(2)), and for the enforcement of individual protective measures. Experience has proved the value of making the commanding officer of each lower unit directly responsible for the incidence of infection within his command. During combat it may be necessary for each man to have a personal supply of suppressive medication with instructions for its use. As soon as practicable, however, the roster method under direct supervision must be initiated for best results.

(7) A list of individual protective equipment that will accompany each man ashore must be prepared including such items as the type and amount of impregnated clothing and bedding, insect repellent and powder, bed net, head net, leggings, suppressive medication if issued, and salt tablets. It is the responsibility of unit commanders to determine that each man has the proper equipment.

(8) No water should be placed in containers for loading on board ship until it has been approved by the Medical Department.

(b) Phase 2.--Assault.

(1) Sanitation personnel should not disembark until the beachhead and surrounding area have been secured; they should disembark with the support group.

(2) Unit commanders should be responsible for the crushing and burial of all tins and similar refuse in their area.

(3) Each unit should be responsible for providing and maintaining, in a satisfactory manner, slit trenches and urine seepage pits in their own area.

(4) Assault and "K" rations (or equivalent individual rations) should be the only ration issued during this phase. There should be no unauthorized cooking or preparation of food until orders covering same are issued.

(5) Drinking water should be obtained only from the appropriate water containers previously approved by the Medical Department. No water should be issued or used by any activity for drinking purposes until it has been authorized by the Medical Department.

(6) Bathing in any fresh or brackish water point should be prohibited until the water point has been declared satisfactory by the Medical Department.

(7) Individual areas for bivouacking small units should not be occupied, if possible, until approved by the unit medical officer. Such areas should always be as far removed as possible from swampy areas, large collections of stagnant water. and native populations and dwellings.

(8) As soon as the tactical situation permits, the sanitation section under the supervision of the malaria and epidemic control officer or the sanitation officer should be charged with the following duties:

(a) Make an immediate survey of the area for mosquitoes, mites, fleas, flies, and other vectors of epidemic diseases within the command zone of action.

(b) Initiate and supervise control measures for the above by the following means:

(1) Spray DDT and other insecticides for larval and adult mosquito control.

(2) Eliminate temporary mosquito breeding sites.

(3) Spray larvicides (sodium arsenite or other approved substance) on all enemy dead, on destroyed carcasses, in latrines, and over garbage dumps or other major fly-breeding areas.

(4) Install flyproof prefabricated latrine boxes and treat them with DDT. Inspect them to assure proper maintenance.

(5) Supervise control measures for flies, lice, mites, and fleas.

(6) Direct proper distribution of epidemic control supplies for the entire command.

(7) Coordinate the sanitary program with that of other commands in adjacent areas.

(8) Keep the commanding officer informed of the incidence of epidemic diseases at all times, and be prepared to make necessary recommendations for their control.

(9) If there is attached to the command a G-19 component, a great amount of assistance can be obtained with the subjects listed under paragraph (8), in addition the laboratory facilities of the G-19 component should be prepared to perform the following: (a) stool cultures for enteric pathogenes; to be done on all admissions for gastro-enteritis, dysentery, or similar diagnoses and food handlers as indicated: (b) parasite surveys, e.g., malaria, filariasis; (c) water analyses; (d) medical bacteriology and helminthology; (e) limited serological

examinations; (f) entomological identifications; (g) limited laboratory investigation and interrogation of local civilian population and P.O.W.'s for immediate determination of endemic diseases, parasites, and so forth.

(10) The Medical Department or the malaria and epidemic control officer will advise the commanding officer concerning malaria as indicated. If suppressive therapy is indicated, unit commanders will be personally responsible for its administration in accordance with instructions as to dosage.

(c) Phase 3 - Occupation or rehabilitation.

(1) Galleys and mess halls may be operated after the following have been complied with:

(a) Adequate flyproofing.

(b) Examination and approval of all cooks, bakers, and mess men by unit medical officers (see chapter I on Messing Sanitation).

(c) Adequate provisions for mess gear sterilization. A recommended procedure is the standard three G.I. can method (large size) with boiling water plus a fourth can which is necessary for presterilization. Water must be soapy in first can. A hospital corpsman should be assigned to be certain that all men immerse their mess gear and that the water is changed as necessary for adequate cleansing and sterilization.

(d) Adequate provisions for flyproofing garbage. If necessary, liberal use of a larvicide is recommended; sodium arsenite has been used with satisfactory results. (See ch. VII, Waste Disposal.)

(e) Mess halls and galleys should not be located in proximity to any area likely to breed flies (latrines, urinals, etc.)

(f) Suitable grease traps, soakage pits, and other sanitary means of disposal for garbage and waste water should be constructed. (See ch. VII, Waste Disposal.)

(g) Flyproof food preparation, issue, and storage rooms should be constructed.

(h) Before operating any galley or mess hall, it must be approved by unit medical officers (Manual of the Medical Department,

(2) A system for periodic inspections should be organized by the sanitation officer. (See par. 25(b).)

(3) Unit medical officers should immediately report to the senior medical officer any insanitary condition and any communicable disease in their area.

(4) The sanitation section should continue their activities as stated, in paragraph 8, Phase 2.

(5) The G-19 component should continue their activities as stated, in paragraph 9, Phase 2. It should also investigate and make necessary recommendations for control and prevention of all communicable diseases.

(6) Non-malarious areas: Because mosquitoes are important vectors of diseases other than malaria, and control measures for the anopheline and other species are similar, it is justifiable to rescind only those items pertaining to suppressive therapy when the command is in a nonmalarious area. All means of personal protection and area control of mosquitoes, should be continued.

11. Immunizations and Inoculations.--While in the staging area, the Medical Department must be certain that all indicated immunizations and inoculations have been administered. Immunization instructions are given in the Manual of the Medical Department,

12. Burial of the dead.-- Burial of the dead is the responsibility of the command, but the Medical Department must assist in planning and must submit recommendations covering procedures for treating and interring the bodies. The plan should strive toward early burial by a practical and sanitary method and should include specific provisions directed against fly breeding. The detailed final plan should be included in the Standard Operating Procedure.

(a) The command will designate a burial officer for each unit within the command and will designate one officer as the command burial officer to be responsible for the entire command. Officers appointed should not be Medical Department personnel but should be impressed with the importance of this task.

(b) The command will provide a sufficient number of men to perform the necessary work. (See par. 3(b)). These men will be in addition to sanitation personnel. (Approximately 1 man per 500 for the command will be necessary). They shall be directly assigned to the command burial officer.

(c) The burial officer for each unit will have sufficient "on call" personnel for the work within his area.

(d) Each unit burial officer will be responsible for burying all enemy dead within his area. If small numbers are encoun-

tered and if it is practicable, depending on the military situation, the task will be performed by the "on call" personnel of his unit. If this is impractical or if large numbers are encountered, then he shall notify the command burial officer stating the exact location, condition, and number of bodies.

(e) The command burial officer shall determine what areas may be used for burial of large numbers of bodies. He shall be responsible for burying all those encountered in the area of the command C.P. and all those referred to him by unit officers within the command. It will also be necessary for him to inspect all areas within the command to be certain no bodies have been overlooked.

(f) All bodies shall be identified as accurately as possible and all materials and personal effects removed must be checked by authorized intelligence personnel.

(g) The optimum depth of burial will vary with the type of soil; the looser the soil, the greater the chance for fly larvae and odors to escape. An average of 6 feet will usually be adequate.

(h) There is no substitute for immediate burial to prevent fly breeding. Bodies should not remain unburied in order to await chemical treatment. Insecticides kill only surface feeding forms, thus only those bodies observed to support fly breeding need to be treated. However, if immediate burial is impractical, then bodies should be sprayed as soon as possible with sodium arsenite solution to kill any surface forms and to prevent further infestation. If fly breeding is noted, the ground where the body is found should be sprayed.

(i) The command burial officer shall be responsible for keeping accurate records concerning number and location of bodies buried.

(j) Suggested supplies for a 50-man detail:

Rakes, long-handled, with long steel prongs	50
Shovels, long handled	50
Pick axes	25
Sprayers, decontamination, 3 to 4 gal. capacity	12
Stretchers	25
Gloves, gauntlet type, pairs	100
Trucks, open body type	3
Rope, ¼-inch, yards	100
Wooden sleds, suitable for towing behind vehicles	5
Sprayer, power type, motor-driven, 50 gal. capacity	1
Additional clothing for members of this detail	---
Bulldozer, on call	1

(k) Miscellaneous:

(1) Unit and command burial officers will maintain close liaison with intelligence sections to assist in collection of intelligence data and materials.

(2) All graves should be clearly marked stating date of burial and number buried, in accordance with the Geneva Convention.

(3) Native labor may be utilized at the discretion of the proper authorities.

(4) Close liaison will be maintained with the Medical Department to assure proper sanitation methods.

Section IV.--INDOCTRINATION AND TRAINING

13. Importance.--Planning and carrying out a training and indoctrination program is one of the important functions of the Medical Department in the staging area. This training and indoctrination to be effective must include all Medical Department officers and all other commissioned and noncommissioned personnel of the organization. Special attention must be given to sanitation personnel.

14. Indoctrination of all Medical Department officers. Outline of Instruction.--A course of instruction in sanitation should be given to all medical officers, dentists, Medical Service Corps and Hospital Corps officers. The S.M.O. can designate one of his officers to prepare a lecture covering each subject. Appropriate bulletins, movies, this Handbook and other available material should be utilized. It is suggested that the following material constitute the course for Medical Department officers:

Subject	Hours	Scope
Prevention and control of disease; housing of troops.	1	Importance, scope, and responsibility for sanitation. Principles of disease control. Control of respiratory disease. Housing standards, ventilation, bed spacing, and sanitation in barracks and tents. See ch. 2,
Personal hygiene	1	Importance of personal hygiene in disease prevention. Personal cleanliness; care of feet, trench foot, skin infection. Responsibility of unit commanders for inspections and enforcement of regulations.

Subject	Hours	Scope
Transmission and control of intestinal diseases.	1	Methods of transmission of intestinal diseases. General principles of control. Role of flies, cockroaches and rats. Emphasis on dysentery. See ch. 13.
Waste disposal	1	Methods of proper disposal of human and kitchen wastes. Construction and maintenance of field devices. See ch. 7.
Mess sanitation	1	General principles of mess sanitation, examination and inspection of food handlers, protection against food contamination, serving of food, dishwashing. See ch. 1.
Water supply; camp sites	1	Types of water supply; procurement, treatment and protection. Field water supply and treatment. Selection and sanitation of camp sites. See ch. 5.
General; louse-borne and flea-borne diseases.	1	General discussion of insect-borne diseases. Prevalence and military importance. Insects as vectors; animal hosts. General methods of control. Control of lice and louse-borne diseases, particularly typhus. Ticks and Rocky Mountain spotted fever. Flea-borne diseases, particularly plague. Rodent control. See chs. 9 and 11.
Importance of and responsibility for malaria control.	1	Military importance and distribution of malaria. Responsibility of all commanders to initiate and enforce necessary measures for malaria control and malaria discipline within their units and unit areas. Organization for malaria control. Malaria survey units; malaria control units; antimalaria detail. See ch. 10.
Methods of malaria control	1	Responsibility for instruction in malaria control. Use of training aids in instruction. Instruction in procedures and equipment for mosquito control. See ch. 10.
Venereal disease	1	Prevalence and importance of venereal diseases; responsibility of commanding officer; control measures. See ch. 14.
Personal hygiene and sanitation in Arctic, desert, and Tropics.	1	Problems of personal hygiene and sanitation in Arctic, desert, tropical and jungle regions--food, clothing, water supply, field sanitation. Special diseases and hazards. Acclimatization; salt and water requirements. Sanitation in a theater of operations. See this chapter.
Field sanitation demonstration	1	Sanitation demonstration area. Field water supply; demonstration of water chlorination; disposal of various wastes; insect control. Use of improvised facilities.
Total hours	12	

15. Training of Sanitation Personnel.

(a) Scope.--Sanitation squads should be trained and equipped to accomplish insect control, rodent control, and general sanitation.

(b) Insect Control.

(1) There are two phases of insect control, the offensive and defensive measures against the adult insects, and, as the situation permits, the attack aimed at preventing their breeding or reaching maturity. The poisons now available include DDT, the most generally useful insecticide, dimethylphahalate, sodium arsenite, paradichlorobenzene (PDB) and other insecticides. DDT is furnished in three forms, (1) concentrate powder, for dissolving in oil, (2) emulsion concentrate, for diluting with water, and (3) 10 percent dust, in either talc or pyrophyllite. The latter may be used as it comes or further diluted with inert dust. DDT kills by immediate contact with the spray or by residual effect. Dimethylphthalate, a clear liquid of low volatility, is used for impregnating clothing, mainly against mites. It may be smeared on, sprayed on full strength, or impregnated by dipping the clothing in a 5 percent emulsion. Sodium arsenite is usually furnished in a 54% solution. It is extremely toxic and should be clearly labeled "Poison". When diluted with 40 or more parts of water it makes a very effective poison for use against fly larvae on dead bodies, in latrine pits, and in old garbage dumps. Adult flies are usually killed at the same time. As arsenic is a cumulative poison, care must be exercised to avoid ingestion or prolonged contact with the skin. Skin rashes have been observed on the back after continued use of leaky knapsack sprayers. PDB is useful only in deep pit latrines. It is a fly repellent and larvicide, and requires no equipment for application.

(2) Complete instructions for the use of these chemicals will be found in this Handbook and in various technical bulletins. The introduction of these insecticides offers possibilities of vastly improved insect control that can be realized through the use of properly trained insect control personnel.

(3) Insect control training should cover the following:

(a) In the staging base: (1) Preparation of insecticide solutions; (2) residual treatment of bed nets and tentage with DDT; (3) impregnation of clothing and blankets with

DMP or DDT as indicated; (4) Fly-proofing procedures and maintenance.

(b) At the forward area: (1) Control of fly breeding with arsenite, PDB, or other poisons; (2) treatment of fly resting places with DDT; (3) use of DDT residue on galley screens, latrine screens, inside living tents, around garbage stands, nearby native huts, etc.; (4) temporary control of mosquito breeding - spraying or dusting DDT; (5) removal, covering, or destruction of insect breeding places; (6) mass dusting of personnel with DDT to control body lice and fleas; (7) cooperation in area disinsectization programs when airplanes are used to spray DDT solutions; (8) area disinsectization by DDT fogs or smokes; (9) bedbug, ant, roach, and other pest control; (10) Repair and maintenance of sprayers and dusters.

(c) Rodent Control.--Personnel should be indoctrinated in the duties concerned with rodent control. For details concerning control measures and proper handling of rodent poisons and traps see chapter 12.

(d) General Sanitation.

(1) The general camp sanitary squad should be trained to accomplish the following: (a) Construct and maintain in flyproof and sanitary conditions all types of latrines; (b) construct and maintain urine soakage pits; (c) construct and maintain showers and wash stands with appropriate soakage pits; (d) construct and maintain trash burners, trash cans, and operate local trash collection service; (e) build and operate incinerators.

(2) The main points to observe in the construction and maintenance of latrines include:

(a) Convenience of location, so as to be used at all times. They may be placed within 30 yards of living areas if properly maintained. With good fly control available, the main factor to be considered is to avoid pollution of wells.

(b) Depth, sufficient for the expected duration. Twenty feet or more is often desirable.

(c) Yeast treatment (in Tropics) to prolong the usefulness of the latrine.

(d) Separation of urine from feces to avoid the usual latrine stench.

(e) Construction of pit and box so that no ledges inside can catch feces or urine.

(f) Possession of several alternate plans for oil drum or bucket-type latrines for use where rocky ground or high water table prevents digging of deep pits.

(3) Urine soakage pits:

(a) Pipes should be small and funnels and troughs so arranged as to permit no accumulation of urine.

(b) Pits should be covered with burlap and earth to keep the odor underground.

(c) Ventilators are of questionable value.

(d) Some degree of porosity of the soil is necessary. It may be possible to dig through an impervious layer to a more pervious one.

(e) Attempt to keep all urine out of the latrine pit by constructing soakage pits and indoctrinating men to use them.

(4) Showers and wash stands:

(a) Earliest possible installation of some of these facilities is desirable.

(b) Waste water should always pass through a scum trap before entering a soakage pit if long life of the pit is desired.

(c) Foot baths of hypochlorite are generally thought to contribute little to the prevention of fungus infection of the feet.

(d) Shower water obtained from reservoirs potentially infested with schistosome larvae should be chlorinated (at least 2 ppm. residual).

16. Training for all Hands.

(a) The indoctrination outlined below is the most important part of personal hygiene and sanitation. If it is done well, the risk from epidemics becomes minimal. If it is not done well, no amount of highly trained sanitation personnel and squads can create a healthy command.

(b) Cleanliness and care of the skin.

(1) Fungus infections and bathing: Frequent bathing and changing to clean clothes is most desirable. During battle, the full uniform may have to be worn continuously for days or weeks. Where possible at least change to clean socks and remove the shoes once a day. Fungus infection of the feet, an extremely common cause of disability, is best prevented by careful washing and drying between the toes. Ointments and foot powders containing salicylic acid should be avoided for routine and indiscriminate use. The standard Navy foot powder (BuM&S

Stock No. 1-204-050) is the best known fungicide for treating and preventing fungus infection of the feet and also of the groin or axillae. Shoes and socks should be dusted. Lowered resistance and recrudescence of infection is more important than new infection through showers, duck-boards, etc. Foot baths are generally considered to be of little value. Men should be warned about use of towels on groin and axillae after contamination by feet. Towels hastily washed, and clothing or towels washed by natives should especially be avoided.

(2) Lacerations, insect bites, etc.: In the Tropics special care must be exercised to protect the skin from scratches, lacerated wounds, and insect bites. Any break in the skin may result in chronic ulceration or impetigo of disabling proportion. Each scratch should be treated promptly with an antiseptic and a sterile dressing. Deficiencies in vitamin, mineral, salt, or protein probably play some role in these chronic ulcers.

(c) Guarding Against Exposure to Heat and Cold.

(1) Heat: In the Tropics sunburn must be avoided expecially by newcomers and blondes. The danger of heat exhaustion may be reduced by acclimatization, by avoiding overexertion in the heat of the day, and by use of light or wet clothing. However, the main preventive measure is maintenance of adequate salt and water intake. These measures, plus proper and clean clothing, are also important preventive measures for prickly heat.

(2) Cold (and Trench Foot): Men entering cold, damp climates or facing the possibility of prolonged exposure must be warned of the seriousness of trench foot and the importance of its prevention. Experience has shown that trench foot occurs when circumstances force men to remain relatively motionless in dampness for extended periods of time with the temperature at 50° F. or lower. Under such circumstances it is imperative that preventive measures be strictly enforced. In some instances it will be necessary to provide special personnel and equipment to dry and resupply socks to men in the front lines. Whenever circumstances permit, in cold, wet weather troops should be relieved from front line action after several days' exposure. Men should be taught that wet socks must be promptly replaced by dry ones, shoes or boots must be kept waterproofed and should be removed at least once

daily to rest, clean, and dry the feet. Foot gear must be loose enough to permit free circulation and the feet and legs must be frequently exercised when circumstances necessitate long periods of standing. The entire body must be kept as warm and dry as possible at all times and particular care must be taken to prevent frostbite.

(d) Adequate and safe food and water.

(1) Enteric pathogens: All hands must be warned against dangers of food served or grown by natives. Dysentery is a common penalty for neglect of this precaution in the Orient where human feces is used as fertilizer. All hands should eat only approved rations, and drink only properly treated water. Some flukes are acquired by eating uncooked shellfish or water chestnuts; schistosomiasis, Weil's disease, and enteric pathogens, by untreated water. The acute diarrheas are often flyborne at first, but infected native help or food handlers or improper care of the mess gear may be the source of many cases.

(2) Food intake: Deficiencies of serious nature result from not eating sufficient food or from the lack of a balanced diet. Adequate food intake is partly a matter of indoctrination. "K" and "C" rations always become dull and monotonous after a time. Men must be taught that the biscuits or crackers are fortified for their health and should be eaten in proportion to the meat or cheese; they must eat their meals whether they are hungry or not.

(3) Liquors, etc.: Warning must be issued against native fermented liquors and preparations containing methyl alcohol. These poisons have caused death and serious illness to combat and garrison troops. Methyl alcohol or liquids containing methyl alcohol should be properly labeled and marked "poison".

(4) Mess gear: Care of the mess gear must be taught. A thorough scrubbing in hot soapy water followed by two rinses in boiling water and air drying should be compulsory. When opportunity exists for contamination of gear between meals, the individual must dip his gear in boiling water before entering the serving line. Pre-sterilization has been found very effective.

(5) Water: Every man in the unit must be taught that the lyster bag, water trailer and water can filled at an approved water point are the only safe and accepted source

of drinking water. Nozzles on water trailers and water cans are sometimes splashed with mud. When this happens they should be rinsed with strong chlorine solution after washing off the mud. Every man must be taught to disinfect his water if it is taken from an emergency source that has not been approved by a medical officer. Directions for sterilizing water in a lyster bag are printed on the cover of the box of hypochlorite ampoules. Four ampoules of hypochlorite powder are used to produce a residual of not less than 3 ppm. after 20 minutes' contact. Directions call for checking the residual and "dechlorinating" with sodium sulfite tablets. Combat troops should be provided with canteen size water purifying tablets. The best for this purpose are the new iodine compounds, which kill cysts of amebic dysentery. Second choice for the individual on his own are Halazone tablets, 100 to a bottle. These are used 2 per canteen of clear water, 4 per canteen of muddy water. Shake well and always wait at least 30 minutes before drinking. All hands should be taught that boiled water is always safer.

(6) Quantity of water: The quantity of water imbibed is very important. When working hard in hot humid climates a man may sweat several quarts a day. Rather than specify any set intake, it is better to advise drinking enough to permit emptying the bladder three times daily. Advise drinking more than thirst alone calls for but also emphasize the importance of water conservation.

(7) Salt intake: The individual must watch his salt intake. When sweating profusely, up to 12 grams (3 level teaspoonsfull) of salt per day may be added to the diet. Salt deficiency causes heat exhaustion, and may be associated with severe headache, prickly heat, and certain other skin disorders. Salt is best added to food at meals. Salt tablets are often nauseating on an empty stomach.

(e) Individual protective measures.

(1) Individual mosquito control.-Rules for individual protection must be simple and uniform. The individual must be taught why and how to avoid mosquito bites. Ignorance and indifference on this point have reduced the combat efficiency of thousands of men because of malaria, dengue, and filariasis.

(a) Always use the bed net, and use it properly. It should have no holes and should be properly tucked in to

make it completely mosquitoproof. Cover the body or apply repellent to the netting or to the skin wherever it may accidently come in contact with the net while asleep. Bed nets treated with DDT will be many times as effective as untreated nets, but repellent is still needed by the restless sleeper. Keep the head net handy; the best place to carry this is in the helmet liner. It can be used on patrols and sentry duty. It has also been used by men who try to get some sleep in the front lines. It may be fastened over the helmet in such a way that the netting will not touch the face or neck while a man is sleeping with helmet on. The latter acts as a pillow.

(b) Repellents.--Either day or night, whenever mosquitoes are biting, use repellent on exposed skin surfaces and where the clothing is thin and tight. Cover every portion of exposed surface with the repellent issued. Use it in addition to the net as described above. Mosquitoes will seek out and bite the smallest untreated area.

(c) Dress.--Keep shirt collars buttoned, sleeves and trousers rolled down. Never go bare waisted or bathe when or where mosquiotes are biting.

(d) Natives.--Keep away from native habitations and keep natives out of bivouac areas. In areas where malaria is prevalent the greatest concentration of infected mosquitoes will be found about native villages.

(e) Drugs.--Follow ALL instructions regarding suppressive drugs. (See below).

(f) Other.--Kill adult mosquitoes by any means at hand, e.g., swat them individually or spray them collectively. Aerosol bombs are least practical when used outdoors or where a breeze is blowing through the enclosure.

(2) Suppressive drugs. It is often impossible to avoid every mosquito bite; therefore, whenever malaria is present and when its incidence is likely to interfere with military operations, suppressive therapy must be prescribed. At present atabrine is considered best and it is safe. Military personnel have taken atabrine continuously for over 2 years. It is preferred to quinine and is more effective. If taken on a full stomach or with plenty of water, it is not likely to cause nausea. The recommended dosage is one tablet daily or seven tablets per week. When taken, it will suppress the clinical manifestations of all types of malaria and will eventually cure most if not all cases of falciparum infection. The administration of any medication when prescribed for suppression of malaria

MUST be enforced. It must never be optional. In addition, all the rules for avoidance of mosquito bites must be enforced both on officers and men. Medical officers must set a good example and do everything possible to stimulate the interest of all officers and men in their organization. Line officers must be made keenly aware of the problems of malaria control and must be made responsible for the enforcement of all regulations.

(3) Mite control. Men must be taught how to protect against mites by the use of insect repellents. A barrier application made by drawing a half inch band around the inside of trouser and shirt cuffs, flies and other openings, with the open mouth of the bottle of insect repellent, is the simplest procedure. Leggings should be worn or the trousers tucked into the socks. Repellent can be smeared on the sleeves and trouser legs by hand or sprayed on clothing by hand spray. Mass impregnation can be carried out in the stageing base by either spraying with full strength dimethylphthalate, 3 to 4 ounces per uniform, or immersing the clothing in an emulsion made of 5 percent DMP, 2 percent laundry soap and water q.s. 100 percent. Men must be warned that DMP-treated clothing may cause a burning sensation on the genitalia unless underwear is worn. CAUTION: Insect repellents are solvents for plastics. Do not use them on synthetic cloth or allow them to come in contact with nonmetallic eyeglass frames, watch crystals, fountain pens, and similar articles.

(4) Louse control. Individual protection against lice consists of dusting 1 to 1 1/2 ounces of DDT louse powder on the underwear or the clothing worn next to the skin. It should be dusted in the hair for head lice. Application may be made by sprinkling from the 2 oz. can or by means of a dust gun. Better protection to troops is afforded in colder climates by prior impregnation of heavy underwear with DDT in dry cleaning solvent or emulsion. If clothing is impregnated with DDT, use DMP only by barrier or hand smear methods.

(5) Flea, tick, etc., control. Individual protection against fleas can be obtained by dusting the clothing with DDT louse powder as described above. All men should know enough to keep trousers tucked in socks or leggings in the presence of crawling insects. Ticks, leeches, etc., may be induced to let go by application of heat (burning cigarette) or irritant (kerosene or iodine). Treat all such bites with antiseptics to prevent infection.

(6) Helminth control. Men must be taught that hookworm is prevalent in the Tropics and is contracted by contact of bare feet or other skin with damp polluted soil. Ascaris and trichuris are contracted by eating with dirty fingers, schistosomes by wading, washing, or bathing in or drinking of polluted water, other flukes by eating raw fish, shellfish, or water chestnuts, and tapeworms by eating raw or incompletely cooked meat or fish.

(f) Disposal of human waste, garbage, and trash.

(1) Feces. All hands must be taught individual responsibility for the disposal of human waste, garbage, and trash in order to prevent the propagation of flies and rodents. Every man must be taught to dispose of feces in a cat hole if straddle trenches or latrines are not available. All hands should know how to dig and use straddle trenches. They need also to know that latrines are built flytight and have lids which must be closed at all times when not in use. In all these methods the object is the same, i.e., cover the feces before the flies can lay eggs in it or get germs out of it.

(2) Urine. Urine rarely presents health problems. It will not breed flies; but men must be taught not to create a nuisance by repeatedly soiling the ground. If men can be taught the advantage of urinating in a soakage pit prior to using a latrine, much of the latrine odor can be avoided. Soakage pits should be properly made with small pipes and small funnels, or they too will have an odor.

(3) Ration containers. Disposal of "K" and "C" rations must be done properly. Men must be taught to put their refuse from each meal in a trash burner or pile and burn it. Emptied or partially emptied ration cans attract and breed flies. Discarded cans and tins will also collect rain water and breed certain species of mosquitoes. When group disposal is impossible, men must be taught to crush their empty tins and to bury all refuse.

(4) Common errors. Cans and bottles should be placed in the trash can or in a pit and buried before mosquitoes have an opportunity to breed in them. Every rain barrel and bucket must be covered, treated with oil or insecticide, or emptied once a week. DDT impregnated cloth or burlap will provide convenient covers. Creation of unnecessary ruts, borrow pits, and holes must be avoided And last, every man must know that dripping food stuff on the ground between the mess hall and garbage stands or other places, will provide food for flies.

17. Insect and Pest Control Supplies and Equipment.

(a) General. These materials are essential to the success of a military mission ashore. When new bases are established supplies will be needed from the first day if serious loss of manpower because of illness is to be prevented. Pest control supplies must be procured and distributed PRIOR to embarkation and TOP LOADED, to be ready for use upon landing. Especially important are insecticides and repellents, and the sprayers and dusters necessary for their application. In view of scientific advances and research, some of the necessary supplies are constantly being revised; responsible officers should be acquainted with recent revisions and allowances as listed in the U.S. Navy Advanced Base Initial Outfitting Lists and the U.S. Marine Corps Table of Basic Allowances.

(b) Initial supply. The materials and quantities listed herein are intended as a guide for a peacetime occupational force. Quantities are estimated on the basis of average consumption per 1,000 men per month in an area where serious insect problems are first being brought under control. Initial supply for a combat organization should be increased 60 to 80 percent.

ESTIMATED USAGE, 1,000 MEN PER MONTH

Item No.	Stock No.	Description and use	Unit	Quantity for Tropic	Quantity for Temperate
1	41-D-4510	Duster, insect powder, plunger type (for use of 10% DDT in personnel delousing, etc.	1	2	2
2	41-D-4530	Duster, rotary blower, 5-10 lb. capacity (for area dusting of DDT powder, etc.	1	1/4	1/8
3	41-D-4525	Dusters, foot pump, for calcium cyanide ''A'' dust (for killing rodents in burrows)	1	1/4	1/2
4	40-N-97-30	Nozzles, insecticide, fan-shaped adjustable spray.	1	--------	----------
5	41-S-4112	Sprayer, liquid, pest exterminator, pump type (plain 1 qt. intermittent ''flit gun''.	1	4	4
6	41-S-4120	Sprayer, 3 qt., continuous spray (for mosquito larviciding, bed bugs, etc.).	1	3	1

ESTIMATED USAGE, 1,000 MEN PER MONTH

Item No.	Stock No.	Description and use	Unit	Quantity for Tropic	Quantity for Temperate
7	41-S-4125----	Sprayer, insect, 3 gal. cylinder type, with accessory larviciding nozzles and spare parts. (For general fly and mosquito control, Penite and DDT).	1----	4	2
8	40-S-2590-18 (Supply at NSD, Oakland	Sprayer, insect, liquid pressure gasoline driven, 50 gal. capacity, skid-mounted, with oil-resistant hose and fittings, pressure regulator, double outlet, insecticide nozzles. (A power sprayer.	1----	1 per 5,000 per year.	
9	33-H- (L-Oak)	Hose, oil resistant, 3/8 in., 200 lb. pressure (for improving or repairing sprayers)	Foot	20	10
10	38-B-2622----	Brush, paint, flat 4'' (for painting DDT solutions on screens, etc.).	1----	2	1
11	42-T-12525---	Traps, mouse, spring type, 3-way snap.	1----	12	12
12	42-T-12700---	Traps, rat, cage type (only for research, live catch).	1----	0-1	0-1
13	42-T-12900---	Traps, rat, spring type (standard rat trap).	1----	12	12
14	51-C-488-----	Calcium cyanide 'A' dust Cyano-gas, 5 lb. cans. (For killing rats and fleas in burrows)	Pound	0	5
15	51-C-452-----	Calcium hypochlorite, high test, Grade A, 5 lb. cans (for medium size hand chlorination of water).	Pound	20	10
16	51-D-190-----	Dichlorobenzine, Para (PDB) coarse granules, 1 lb. can (fly control in pit latrines).	Pound	150	0 in winter
	51-D-192-----	----do--in 100 lb. drum--			
17	51-I-157-5---	Insecticide, DDT concentrated powder, 5 lb. can (for dissolving in oil solutions, not for dusting).	Pound	80	40
	51-I-157-25--	----do--in 25 lb. can			
18	51-I-157-500	Insecticide, concentrated solution, DDT-xylene-emulsifying agent, 5 gal. (to be diluted with 4 parts water for general spray purposes).	Gal.	20	20
19	51-I-157-600	Insecticide, diluted powder, 10% DDT, 5 lb. can.	Pound	For small ships.	
	51-I-157-610	----do--in 25 lb. can (for delousing and DDT dusting, roach control, etc.).	Pound	100	100
20	51-I-165-----	Insecticide, liquid Navy Standard, 1 gal. can. New formula contains DDT.	Gal.-	10	10

Item No.	Stock No.	Description and use	Unit	Quantity for Tropic	Quantity for Temperature
21	51-C-2031-10	Insecticide, Aerosol dispenser, 1 lb. bomb (refillable) (This material intended for killing adult mosquitoes, not flies. Containers should be saved and refilled.)	Each	100	30
	51-C-2031-25	----do--Recharging cylinder, 40 lb.	Each	8	4
22	51-G-120-50--	Gas, Aerosol for recharging above.			
23	51-D-237-400	Insecticide, repellant, 2 oz. bottle. Personal use, type A. (Dimethylphthalate.)	Each	0-1,000	0-500
	51-D-237-425	----do--1 gal. type B (for treatment of clothing against mites).	Gal.	0-48	0-48
	51-E-572-----	Roach exterminator tablets (type B)	Pound	1-4	0-2
24	51-I-171-----	Insecticide, powder for body lice, 2 oz. can. (DDT louse powder.)	Each	0-200	0-1,000
25	51-M-888-----	Methyl bromide ampoules-	Each	Only for delousing teams.	
26	51-M-889-----	Methyl bromide, 1 lb. cans (for special mass delousing by trained teams, 10% DDT is better and safer).	Pound	Only for delousing teams.	
27	51-S-4840----	Red Squill, fortified, rat poison. 25 lb. container.	Pound	--------	----------
28	51-S-2333---- fly breeding.	Sodium arsenite, concentrated solution 54% 30-gal. drum. (For emergency control of fly breeding. To be diluted with 40 parts of water.)	------	--------	----------
*29	51-T-4511----	Thallium sulfate, 1 lb. container.	Pound	1/2	1/2
30	51-T-5751----	Trichlorethylene, 5 gal. can (for making special concentrated solutions of DDT).	Gal.	Special only.	
*31	51-Z-371-150	Zinc phosphide (rat poison), pound.	Pound	1/2	1/2
*32	51-S-3339---- (JAN-R-390)	Sodium monofluoracetate '1080' (rat poison) 1/2 lb.	Pound	1/2	1/2

*To be issued only to rodent control officers. These items are deadly poisons.

(c) Resupply: The above list as given under initial supply may also serve as a guide for re-supply. This list is not intended as a block supply and it is assumed that only those items and quantities actually needed will be requisitioned. (Note: All stock numbers are subject to change.)

18. Malaria control and/or sanitation equipment.

(a) Screening: The amount and type of screening needed will vary with the operation (combat or occupation) and the geo-

graphical location. The latter combined with medical intelligence data, etc., will indicate the diseases and insect vectors to be expected. Enough material to screen the tropical disease wards of field hospitals should come ashore with the hospital units. This would be followed by material to screen other structures as soon as practical. The recommended priority for screening is as follows: field hospitals, latrines, galleys, mess halls, officers, and later all tents if indicated. Cloth bobbinette or mosquito netting is preferred to wire for field use. Wire or plastic screening is preferred whenever wooden mess hall, or other semipermanent buildings are to be screened.

The following amounts of screening per unit of 1,000 men per month are suggested for a malarious area:

Screening, cloth-bobbinette, 18-20 mesh, bar 3 ft. wide 10,000 linear feet (initial supply only).

Screening, cloth-bobbinette, 18-20 mesh, bar 3 ft. wide, 2,000 linear feet (replacements 1,000 per month).

Screen, wire, heavy grade, 16 meshes to the inch; screen standard grade, 18 meshes to the inch; or plastic screening may be issued in lieu of cloth when use of permanent building is anticipated. Replacement rate should be half that of cloth screening.

(b) Additional Equipment: The following is a suggested list of additional equipment necessary for malaria control and/or field sanitation:

ENGINEER EQUIPMENT

Article	Unit	Per 1,000 men
Compass, lensatic	Each	1
Machetes, with scabbard	Each	8
Paper, overlay or tracing, for maps	Roll	1
Quartermaster equipment:		
Axe, single bit, with handle	Each	3
Brush hook, with handle	Each	2
Hammer, carpenter, claw, ball-faced, 1 lb.	Each	2
Notebook, field	Each	6
Mattocks, with handles	Each	5
Saw, cross-cut, type L, 2-nose, 6 feet	Each	1
Scythe, brush, with handle	Each	2
Shovel, D-handle, square point No. 2	Each	3
Shovel, long handle, round point	Each	3
Shovel, long handle, square point	Each	3
Soldering outfit	Set	1
Stone, carborundum	Each	1
Boots, rubber, hip, sizes 7-11	Pair	6
Boots, rubber, knee, sizes 7-11	Pair	6
Funnels, with 1-inch aperture, lower	Each	3
Signal equipment: Flashlight	Each	7
Medical supplies--Class 7:		
Dipper, 1 pint, white enamel	Each	3
Book, memorandum	Each	12
Book, blank, ledger	Each	1
Bottles, 1 ounce	Doz.	1
Medicine dropper	Each	6
Pencils	Doz.	2
Pencils, blue	Each	6

Article	Unit	Per 1,000 men
Medical supplies--Class 7--Continued:		
Pencils, drafting, 6H	Each	6
Pencils, red	Each	2
Ruler, 12-inch	Each	2
Ordnance equipment:		
Files, flat, mill bastard, 12-inch	Each	2
Spigots for 55-gallon oil drums	Each	4

19. Airplane spraying of DDT: (See ch. 9, sec. III). If airplane spraying is contemplated and has been officially approved by the proper authorities, the following information will be of assistance:

(a) Recommended solvent: Fuel oil #2 or diesel oil av. wt. 7.2 lb./gal.

(b) Recommended concentration:

(1) Ten percent solution of DDT. Prepared by diluting concentrated stock solutions containing special solvents, e.g., trichlorethylene,(WARNING. Fumes from chlorinated hydrocarbons are dangerous and preparations employing them should not be made in enclosed places).

(2) Five percent solution of DDT obtained by using 20 lb. DDT concentrate powder per 55 gal. drum (7 oz/gal.) of diesel oil. (Must be agitated until DDT is all in solution.)

(c) Recommended dosage: Two quarts per acre of 5 percent concentration.

(d) Recommended allowance: 1,250 pounds of DDT concentrate powder per month for each square mile to be sprayed (this would allow for 10 sprayings).

20. Miscellaneous: The malaria and epidemic control officer or sanitation officer should maintain close liaison with the quartermaster or supply officer and the engineers in order to obtain miscellaneous supplies and equipment as needed. Supplies such as lumber, nails, etc., should be available if necessary. Trucks and bulldozers may be needed for special details such as providing and maintaining garbage disposal facilities and the burial of large amounts of refuse.

21. Camp Selection.

(a) Advance quartering party.

(1) Organization. A quartering party composed of a staff officer, a medical officer, necessary assistants, and representatives of subordinate units will make preparations for quartering a command. The staff officer is the chief quartering officer. Quartering arrangements are completed prior to the arrival of troops.

(2) Duties. Subject to the approval of the area commander, quartering parties select the area, make detailed arrangements for its occupancy, apportion areas to subordinate units and allot to each the available facilities. They also reserve those areas necessary for administration and supply facilities for the entire command (headquarters, hospitals, dispensaries and message centers.) If possible, arrangements will be made for essential sanitary installations prior to the arrival of the main body. The proposed source of water supply should be determined and guards posted to prevent contamination of the selected source or the use of unauthorized sources. Initial provisions must be made for adequate treatment of the proposed water supply and for disposal of human excreta, garbage, and other wastes. Arrangements for the construction of permanent sanitation facilities should be completed as soon as possible, preferably prior to the arrival of the entire command, if the camp is to be a semi-permanent or permanent base.
or permanent base.

(b) Essentials of selecting a camp site.

(1) General considerations. The selection of camp sites is governed by both military and sanitary considerations. As far as the tactical situation permits, security, supply, sanitation, administration, and the comfort of troops govern the selection of bivouac sites. At times the military situation may require the selection of a camp site which is not entirely desirable from a sanitary standpoint. However, full weight should be given to sanitary considerations provided that they do not interfere with the military mission. Medical officers are responsible for making sanitary surveys of prospective camp sites, and making recommendations as to their suitability. It will

be advisable for larger units to request recommendations from the Engineer Corps and Supply or Quartermaster Corps.

(2) Specific considerations. From the sanitary and hygienic standpoint, the following features are desirable:

(a) Healthful environment in regard to mean temperature, humidity, and average rainfall.

(b) Lack of insect vectors and human and animal reservoirs associated with diseases of epidemic and endemic importance.

(c) Accessibility to a supply of good water and fuel.

(d) Sandy loam or gravel soil, favorable to waste disposal.

(e) Firm, grass-covered turf.

(f) Elevated, well drained site.

(g) Sufficient space to avoid overcrowding and to permit proper spacing of galleys, mess halls, housing areas, and latrines.

(h) A good road network.

(i) Shade trees as protection from sun in hot weather and protected slopes or trees to act as windbreaks in cold weather (also important consideration for camouflage).

(j) Firm ground for vehicle parking, etc.

(3) Undesirable locations. Sites with the following characteristics should be avoided if possible.

(a) Dry beds of rivers, ravines, or the base of a hill if there is likelihood of rains.

(b) Clay or loose, dusty soil.

(c) Marshy grounds or areas near stagnant water courses which may constitute sources of mosquito-borne disease and be subject to mist or heavy dew.

(d) Ground water less than 4 feet from the surface of the ground.

(e) Steep slopes.

(f) Locations close to native villages, especially in malarial and filarial regions.

22. <u>Camp Organizations.</u>

(a) General. Experience has proved the value of having each subordinate unit within a camp area complete within itself. When this arrangement is followed, the opportunities for spread of disease within the camp from unit to unit are greatly reduced. Insofar as possible each subordinate unit should maintain separate facilities for the following: galleys, mess halls, housing areas, latrines, laundry and wash racks, recreational buildings, theaters, athletic areas, post exchanges, ship's service, post

officer facilities, barber shops and prisons. Special consideration must be given to the location of the galley, mess hall, and housing area in relation to each other and to latrines, urinals, roads, prevailing wind direction, and landscaping. The plans for camp organization and construction should be approved by the Medical Department. Man-made sanitary hazards must be avoided. Particular attention is necessary to avoid man-made mosquito breeding places. Close cooperation with the engineers will be required to avoid interruption of natural drainage, inept selection of borrow pit sites, poor sumps and road ruts.

(b) Arrangement of sanitary facilities.

(1) Latrines and urinals. (For complete details see Chapter 7 on Waste Disposal.)

(a) Construction should be made where waste will not pollute the water supply. If possible disposal units should be located downwind of the prevailing wind direction at least 100 yards from the galley and 30 yards from the housing area.

(b) Facilities should provide for 16 feet of straddle trench per 100 men or one latrine seat or space for each 10 to 20 men, depending on the size of the unit. Latrine construction must be in accordance with approved (flyproof) methods and pits must be deep enough to provide long service (15 to 20 feet.)

(c) Construction should allow for 5 urine pipes for each 100 men, and 1 urine soakage pit for each 200 men. Urine pipes should not enter latrine pits.

(2) Galleys and mess halls. (For complete details see fig. 1 on messing sanitation.)

(a) Locate at opposite end of street or area from latrines.

(b) Provide 1 soakage pit with barrel or baffle grease trap for each 200 men, to be replaced as often as necessary.

(c) Allow for adequate and safe arrangements for mess kit sterilization.

(d) Refuse disposal must be provided for by either burial, dumping at sea, or incineration. Strict sanitary measures are necessary and the methods used must conform to approved fly and rodent control programs.

(e) Adequate screening against insects must be provided.

(f) Equipment and design should include provision for rodent control.

(3) Water Supply: This is discussed separately in Chapter 5 of this Handbook. In general, the water source should be sufficient to provide the following minimum consumption per man per day.

	Gallons
Semipermanent to permanent camps	20 to 50
Temporary camps	5 to 10
Bivouac or marching	2
Absolute minimum during combat	1

Normally, animals will require an average of 10 gallons per day.

(4) Dumps. The dump should be located at least 1,000 yards from the housing area and, preferably, 1,000 yards from the camp boundary. Its size is dependent on the size and permanency of the camp. Details for waste disposal, dumps, etc., are contained in chapter 7 of this Handbook.

(5) Closing a camp. Prior to leaving a camp site, all sanitary installations must be closed and left in a manner such that they will not constitute an insect or rodent menace. Latrines, soakage pits, grease traps, dumps, etc., shall be filled and/or covered with earth. Larvicides and rodenticides will be used as indicated. Signs or appropriate markers will indicate the organization, the nature of the installation and the date of closure.

(c) Housing. Complete details on barracks housing are given in chapter 2 of this Handbook.

(1) Important considerations. The principal housing considerations are as follows: (a) Approved ventilation, heating and lighting; (b) proper bed spacing; (c) prevention of overcrowding; (d) maintenance of cleanliness; (e) adequate and approved bathing and toilet facilities; (f) adequate insect and rat proofing.

(2) Tents. In any semipermanent or permanent camp, the tents shall be arranged in rows along company streets with appropriate bathing, laundry, and wash rack facilities at one end. Latrines may be placed at the same end of the company street provided it is set at least 100 yards away from the galley. Urine soakage pits, properly constructed and maintained, should be conveniently located in order to prevent indiscriminate urinating. Labeled trash cans and periodic collection of trash should be provided. Water buckets for fire must be appropriately covered or treated and inspected regularly to avoid mosquito breeding. Food and its preparation should be prohibited in all tents. Weatherpermitting, the sides of the tents should be rolled

daily and the hood opened. Bedding should be aired twice weekly and cots cleaned with soap and water at intervals. If tent floors are provided, they should be kept oiled, and dry sweeping should be prohibited. Tents and the tent area should be policed daily. Weekly inspections by the commanding officer or his representative, and the medical officer should be strict to insure these provisions and disciplinary action should be taken as indicated.

(d) Barber and barber shops. Insofar as possible, the following sanitary regulations should be enforced in any field activity located in a semipermanent or permanent camp. These regulations should be conspicuously posted in every barber shop.

(1) Barber shops:

(a) No shop will be established without the approval of the commanding officer.

(b) Shops will not be located in barracks or other rooms where men sleep.

(c) They will be properly and adequately lighted and ventilated.

(d) The walls, ceilings, furniture, and other exposed fixtures shall be kept clean and free from dust.

(e) The floors will be kept oiled and dry sweeping shall be prohibited. The floor shall be mopped at least once daily.

(f) Adequate provisions will be made for hot and cold running water and waste disposal.

(g) The headrest of chairs will be covered with a clean towel or sheet of paper for each individual patron.

(h) A freshly laundered towel will be used for each individual patron.

(i) All brushes, combs, razors, clippers, scissors, tweezers, buffers, etc., will be thoroughly cleansed and sterilized after each separate use. Sterilization may be accomplished by immersing some articles in an approved antiseptic solution.

(j) The use of powder puffs, sponges, neck duster, and styptic pencils will be prohibited; liquid styptics may be used with individual applicators.

(k) No service will be given to personnel with any skin disease or infectious disease of any type. The barber will report these cases to the medical officer and will require a medical certificate before rendering them service.

(2) Barbers:

(a) Before any person, enlisted or civilian, is employed as a barber, he will read all regulations pertaining thereto and express the intention of complying with them.

(b) Each barber will be required to undergo a monthly physical examination and to submit to such other examinations and tests as may be necessary to exclude communicable diseases.

(c) Barbers will keep their persons and clothing clean and should wear a clean, washable outer coat or uniform.

(d) They will wash their hands thoroughly with soap and water before attending each patron.

(e) Barbers will not, under any circumstances, treat or prescribe for any lesion or disease of any kind; they will not sell or give away any medicinal preparation for treatment of any lesion or disease condition.

(e) Prisons. Navy Regulations states, "Cells for the confinement of prisoners shall not be less than six feet long, three and one-half feet broad, and six and one-half feet in height, and shall be properly ventilated. They shall not be altered without the authority of the Secretary of the Navy". The sanitary standards for prisons are the same as those for barracks. Chapter 2 of this Handbook on housing discusses these in detail. The medical officer will inspect the prison on his weekly inspection of the camp. The Manual for Naval Places of Confinement, BuPers, gives the duties of the Medical Department as they pertain to prisons and prisoners.

23. Sanitary Supervision. Supervision of the sanitation of a station or command is one of the most important duties devolving upon a medical officer. Inspections and reports should not be made in a perfunctory manner. Recommendations should be specific and suggested plans must be practicable. Judgment as to the degree of danger to the health of the command must be accurately conveyed to the commanding officer. Potentialities for serious epidemics should be foreseen well in advance and strong warnings given if conditions favor the propagation of vectors of malaria, dengue, filariasis, typhus, and other insect-borne diseases, or if the use of polluted water and inadequate sterilization of mess gear is noted. On the other hand a balanced outlook, giving proper consideration to military exigencies, must be maintained, and defects of minor importance should be given only such stress as the situation warrants. In these matters a careful evaluation of the risks is a part of the duty of the medical officer.

24. Sanitation Bills.

(a) Purpose. In order that the medical officer's responsibilities in all matters relating to hygiene and sanitation are discharged efficiently, it is desirable to prepare a set of sanitation regulations or a sanitation bill, for the commanding officer's approval. Written instructions will enable the medical officer or sanitation officer to organize properly his work, to establish a routine for making inspections, and to secure prompt action on recommendations for needed improvements. The sanitation bill should also designate the duties and responsibilities of all personnel within the command. Medical officers concerned with sanitation should keep accurate records on all inspections, recommendations, memoranda, etc.; complete records are invaluable for the preparation of quarterly and annual sanitary reports.

(b) General considerations. When a sanitation program is planned and sanitation bills to guide its execution are prepared, the following should be kept in mind:

(1) All factors pertaining to sanitary installations and hygiene of personnel, including civilian, are the concern of the senior medical officer.

(2) Cooperation with local, State, Territorial and Federal public health authorities is essential to coordinate the Navy program with civilian public health efforts.

(3) When possible and desirable, use should be made of available consultant services offered by local public health agencies.

(4) Approved laboratory procedures and testing equipment should be used to examine milk, water, food, food handlers, galley equipment, waste disposal, etc.

(5) The duties, laboratory equipment, and capabilities of specially trained components (G-17, G-18, G-19, and G-22A) should be fully realized and incorporated in the Sanitation Bill.

(6) Officers concerned with sanitation should keep abreast of latest advancements in the science of preventive medicine and should be thoroughly familiar with this Handbook and current directives and information from the Bureau of Medicine and Surgery.

(c) Special considerations. A practical and intelligent Medical Sanitation S.O.P. and/or Sanitation Bill based upon a thorough knowledge of field sanitation, preventive medicine,

and local environmental conditions, should preclude the necessity of special directives. However, when epidemic or endemic disease threatens or is acutally present in the area where the command is operating, it might occasionally be necessary for the senior medical officer or sanitation officer to issue directives through his commanding officer for the prevention or control of such diseases. Special directives might be needed to cover the following:

(1) Mosquito control. Individual control methods and suppressive therapy must be rigidly enforced in an area where any of the following are present: malaria, dengue fever, filariasis, yellow fever, dengue-like fever, and encephalitis.

(2) Fly control. A fly control directive should include instructions for use of chemicals in the treatment of latrines and other fly breeding sites, the time interval between treatments, maintenance of insectproof structures and for obtaining the necessary fly-control supplies.

(3) Dysentery control. In addition to fly control, directives should be issued for: physical examinations and compulsory stool cultures on all food handlers prior to their assignment to duty, discontinuance of rotation of such personnel until the emergency has ceased, restriction of liberty for all personnel, prohibition of eating at any other than approved mess halls, isolation and treatment of all patients and carriers, increased supervision of the water supply with periodic standard bacteriological and chemical analysis to determine potability and adequacy of treatment, and any other emergency measure that may be advisable.

(4) Other examples. Directives should be issued for the control of any diseases such as: other insect-carried diseases (typhus fever, etc); other water-borne diseases (amebic dysentery, schistosomiasis, etc.); plague, and other diseases spread by rodents.

25. Reports.

(a) Reports to the Bureau. The Manual of the Medical Department gives instructions for these reports, which includes the following:

(1) Special reports.- Special Epidemiological Reports and Intelligence Reports.

(2) Weekly Morbidity Report.

(3) Monthly Morbidity Report.

(4) Annual Report of Arsenicals (NavMed Form -A)
(5) Semi-annual Sanitary Reports.
(6) Annual Sanitary Report from ships.

(b) Reports within the commands. In order that the senior medical officer and sanitation officer can intelligently perform their duties and submit pertinent memoranda and recommendations to the commanding officer, there should be established a system for sanitary inspections and reports within the command. Since subordinate unit medical officers within the command will be required to make weekly sanitation inspections with their commanding officer, a weekly report to the senior medical officer or sanitation officer can be submitted without involving a great deal of extra work. To expedite this additional reporting and to make it as complete and efficient as possible, a standard inspection sheet in the form of a graded check-off list should be devised for the command. A copy of this should be retained by the unit medical officer and copies should be submitted to the unit commanding officer and the senior medical officer or saniation officer. Space for pertinent recommendations should be provided and appropriate action taken when indicated. In addition to this system, the sanitation officer will find it desirable to conduct spot inspections at his discretion.

Chapter 9

Properties and Uses of DDT and Insect Control Measures

Section I.--INTRODUCTION

1. Chemical and Physical Characteristics

(a) The insecticide now almost universally known as "DDT, formerly referred to by various names, such as "Gesarol," "Neocide," or "SBLY," is a chemical synthesis of dichloro-diphenyl-trichlorethane (1-trichloro-2, 2-bis(p-chloro-phenyl) ethane.)

(b) In the commercially pure form procured by the armed forces, DDT is a fine white powder. DDT particles in this form show a tendency to lump, a tendency which is also present in dusts having a DDT content greater than 10 per cent.

(c) DDT deteriorates at a very slow rate when exposed to the atmosphere and to sunlight; the residue on a sprayed surface retains its effectiveness as a contact poison for several weeks. It is not destroyed by temperatures encountered in ordinary storage on board ship or in tropical stations.

(d) The physical properties of DDT are such that it may be dispersed in oil solutions, in emulsions, or in diluted dusts; it is insoluble in water.

2. The Development of DDT

(a) DDT was first synthesized by a German chemist in 1874, but its insecticidal properties were not discovered until 1939, when a Swiss chemical firm began to use it in the control of moths and plant lice. The U. S. Department of Agriculture tested samples of DDT in November, 1942 and found it to be effective against insects. Experiments subsequent to that time

were directed toward determining the best means of employing DDT against the insects which continually threaten the health, morale, and military efficiency of our troops, Until late in 1944, DDT was available only in the quantities adequate for such experimentation.

(b) In 1943, when the Department of Agriculture Laboratory at Orlando, Florida began sending its reports on DDT to the Army and the Navy, many of the accounts were difficult to believe. Ducks from a pond which had been treated with DDT for larvicidal action moved over to a large puddle and resumed their swimming. All the larvae in the untreated puddle were later found to have been killed. Flies being saved for another experiment were unintentionally killed when DDT dust was mixed at a great distance from the cage in which they were confined. Laboratory technicians with traces of DDT on their hands ruined experiments when they picked up small cages in which experimental insects were kept. It was also reported that one (1) part DDT in 20,000,000 parts of water killed 100 percent of mosquito larvae: one (1) part in 100,000,000 parts of water killed 40 percent of larvae. As reports continued to come in, it was realized that DDT could be made to accomplish all the feats ascribed to it and many more.

(c) The prolonged residual effectiveness of DDT against insects constitutes its main advantage over previously used insecticides. Furthermore, minute doses produce lethal action on most insects. Ingestion of DDT by insects is not required since absorption takes place from the surface of the insect's body and its extremities. Finally, when suitable precautions are taken, DDT may be used as an insecticide without appreciable risk to human beings (see Section IV.)

Section II.--THE FORMS OF DDT INSECTICIDES AND THEIR APPLICATION

3. Forms in Which DDT is Supplied by the Navy.

The U. S. Navy stocks DDT insecticides in both concentrated and diluted forms either for direct application as powders or in liquid or powder concentrates from which solutions and emulsions may be prepared. The following stock items of DDT can be procured from the Bureau of Supplies and Accounts:

(a) Insecticide-Concentrate, DDT Powder (commercially pure DDT) is supplied in 5 pound (Catalog of Navy Material, Stock Number 51-I-157-5) and 25-pound (Catalog of Navy

Material, Stock Number 51-I-157-25) airtight cans. This material is sued as a basic compound for making oil solutions for use in controlling mosquito breeding; and for use against flies, fleas, bedbugs, cockroaches, etc.

(b) Insecticide-Concentrate, DDT Solution (DDT-xylene-emulsifying agent) is supplied in 1-gallon (Catalog of Navy Material, Stock Number 51-I-157-475) and 5-gallon drums (Catalog of Navy Material, Stock Number 51-I-157-500.) The formula under which procurement is made consists of 25 percent DDT, 68 percent xylene (solvent,) and 7 percent Triton X-100 (or other acceptable emulsifier.) This is the concentrated stock solution from which the water emulsion is prepared. (This material is prohibited aboard ship, because of the explosive properties of the xylene solvent.) For use aboard ship, Insecticide-Concentrate, Liquid, Water-Emulsifying (DDT-Non-Explosive Solvent-Emulsifying Agent) (Catalog of Navy Material, Stock number 51-I-156-50) - 1 -gallon can (Catalog of Navy Material, Stock Number 51-I-156-55) -5-gallon pail - Specification 51-I-19 is recommended.

(c) Insecticide Powder (10% DDT) is supplied in 5-pound (Catalog of Navy Material, Stock Number 51-I-157-600) and 25-pound (Catalog of Navy Material, Stock Number 51-I-157-610) cans for use against lice, roaches, flies, etc.

(d) Aerosol cylinders are supplied as 1-pound refillable dispensers (Catalog of Navy Material, Stock Number 51-C-2031-10). When requesting filled cylinders, the gas (Stock Number 51-G-120-151) must also be specified. Aerosol insecticide for refilling the 1-pound dispensers is supplied in 40-pound capacity recharging cylinders (empty cylinders - Catalog of Navy Material, Stock Number 51-C-2031-25), (gas-Stock Number 51-G-120-70). Empty 1-pound dispensers must be returned to stations equipped for refilling. The aerosol insecticide contains pyrethrum, sesame oil, and freon. The formula is effective against mosquitoes.

(e) Delousing Powder (for body lice) Catalog of Navy Material, Stock 51-I-171) is supplied in a 2-ounce can for use as a louse powder. This is 10 percent DDT in pyrophyllite. The Insecticide Powder (10%DDT) mentioned in Par. 3(c) above may be used in treating large groups of individuals when mass dusting programs are indicated.

4. Forms in Which DDT may be Applied.

(a) General. - The amount of DDT applied is the important factor in DDT dosage rather than the total amount of the mixture; the amount of diluent is important only in that it should be adequate for even distribution of the active ingredient. For example, 2 quarts of 5 per cent DDT in oil contains the recommended larvicidal dosage per acre (0.2 pound of DDT.) With

the equipment now available, it is difficult to distribute material uniformly over such an area.

were available in almost all theaters of operation. In larval control, DDT requires a much smaller amount of oil and gives longer control than other larivides. DDT goes into solution in oils rather slowly, full saturation at normal weather temperatures requiring from 12 to 24 hours. Heat will hasten the process if the oil is placed in the sun and stirred occasionally. Two and one-fourth (21/4) pounds of DDT in 5 gallons of oil yields a 5 per cent solution (On the formula, weight/volume: DDT/oil,) each 100 ml of solution contains 5 gms of DDT. If commercially pure DDT is placed directly into a large drum of oil, a tenacious gummy coat forms on the lumps of DDT and prevents complete solution. It is better to break up the lumps and mix the measured amount of DDT into a relatively small amount of oil. Experience gained in the field during the war period with various types of oil and kerosene solutions may

(1) Diesel oil gives excellent results, having a viscosity well suited to the sprayers now in use. It will dissolve 10 grams of DDT per 100 cubic centimeters. Grade known as cetane 45 is a 30 percent better solvent than cetane 50, at all working temperatures. Cruder oils are generally better solvents.

(2) Lubricating oil #10 and crank-case oil are slightly less desirable than Diesel oil. They should be thinned by the addition of kerosene or diesel oil if a fine or semifine spray is needed. Spreading of the oil film is a very important factor.

(3) Kerosene (crude) will dissolve 5 to 8 grams of DDT per 100 cubic centimeters. Purified kerosene will dissolve only 2 to 4 grams per 100 cubic centimeters. These solutions are well adaptedfor use as a fine, fog-like spray against adult insects; they are also recommended for use as residual spray where darker oil stains should be avoided, as on walls and mattresses.

(4) Fortified oil solutions, in which the solubility of DDT is increased by the addition of cyclohexanone, xylene, Velsicol, or other solvents to the oil, may be recommended for particular uses, such as in combat areas where oil is difficult to transport, for spraying from planes, etc. Concentrated oil solutions are particularly dangerous upon contact with the skin. Halogenated hydrocarbons, such as tetrachlorethane and carbon tetra-

chloride, must not be used for increasing the solubility of DDT in oil. The choice of solvent depends on the method of application and the insecticidal use of the solution. Many solvents are flammable, some highly so. Solvents of low flash point, such as xylene, may create highly explosive concentrations in the air when used in unventilated enclosed spaces. The solubility of DDT in a few of the more useful solvents at 27° - 30° is as follows:

Solvent	*Grams per 100 ml.*
Cyclohexanone	116
Xylene (10 degree)	53
Petroleum oils:	
Stoddard Solvent	.9
Kerosene, crude	8-10
Kerosene, refined, odorless	.4
Fuel oil No. 1	8-11
Fuel oil No. 2	7-10
Coal-tar light oil distillate fractions:	
Hi-Flash solvent	48
Heavy solvent	58
k-327 (chiefly methylnaphthalenes)	67
Aromatic petroleum fractions:	
Velsicol AR-50 (chiefly mono- and di-methylnaphthalenes)	55
Velsicol NR-70 (chiefly tetramethylnaphthalenes)	52
S/V Culicide Cil B (chiefly methyl and polymethylnaphthalenes	48
PD 544-B (middle fraction of S/V Culicide Oil B)	45
PD 544-C (new fraction of S/V Culicide Oil B)	44
Solvesso No. 3 (aromatic fraction, medium boiling range	33
APS-202 (refined, high boiling fraction of S/V Culicide Oil B)	45

(5) Emulsions.--DDT in the form of an emulsion is preferred for convenience when residual effect on special surfaces is desired, as in galleys, in living quarters, and for use in the impregnation of clothing. In landing operations or at other times when transport is limited, it affords an 80 percent saving of transportation, since it is diluted with 4 (or more) parts of water prior to use. Under ordinary circumstances the emulsion, in view of its cost, should not be used for large scale projects for which diesel oil or kerosene is suitable and more economical. When received in shipment the concentrated "stock" solution may be preserved indefinitely if the container remains tightly closed. Diluted with 4 parts of water and thoroughly agitated, the solution makes a 5

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percent DDT emulsion; any clean water, including rain or river water, sea water, brackish or hard water, may be used. If the emulsion is to be used as a larvicide, dilution to 1 or 2 percent DDT assures more uniform surface coverage than use of the 5 percent strength. Any spraying apparatus must be thoroughly washed and rinsed or oiled after use to prevent corrosion of the metal parts; this corrosive effect makes the emulsion unsuited to dispersal from planes. A creamy layer may sometimes form at the surface of an emulsion; when this occurs the emulsion has been broken and it should be thoroughly stirred before being poured into the sprayers for use. Since the effectiveness of the diluted emulsion begins to decrease after 24 hours, only the amount required for a particular day should be mixed at one time.

(c) Dust. - Ten per cent DDT in talc or pyrophyllite has certain disadvantages. It requires shipping of the 90 per cent diluent, and has an extreme susceptibility to wind. On the other hand it is rapidly dispersed and readily absorbed by insects. The 10 per cent strength is required for use against lice, fleas and cockroaches; more dilute dust (1 to 5 percent) is effective against flies, mosquitoes, and mosquito larvae. The 10 per cent dust issued by the Navy may be diluted with condemned flour, fine road dust, soapstone, slaked lime, etc.; thorough mechanical mixing is required. Concentrated DDT powder (100 Percent) must not be diluted in the field for use as a dust, since the required small particle size cannot be produced without heavy grinding equipment.

(d) Aerosol Bombs. - Bombs supplied by the Navy do not contain DDT, they have only a temporary effect on flies and most other insects and are intended for use solely against mosquitoes. Aerosols containing 0.4 per cent pyrethrins with 3 per cent DDT have been shown to be a nearly perfect all-purpose insecticide, and will probably be supplied when present stocks are depleted. The aerosol is however, too fine for use as a residual DDT spray. The use of DDT in aerosol bombs now plays a prominent role in the disinsection of planes and in a reduction in the indicence of dysentery, malaria, dengue, filariasis, and other insectborn diseases.

5. Meteorologic and Other Conditions Affecting the Use of DDT

(a) Rain. - When freshly applied and still wet, DDT residues are easily washed away by rain. After drying, DDT tends to stick to surfaces, but a considerable amount is washed away by repeated or heavy rains; small bodies of water have

been found to contain DDT in larvicidal concentrations as a result of the insecticide's being washed into them from vegetation and other surfaces. The spilling over of nonflowing bodies of water decreases the DDT content, requiring more frequent larvicidal application.

(b) Wind. - If favorable winds of low velocity prevail, fine sprays, dust, aerosols, and smokes may be driven by the wind through an area; this is particularly helpful in treating inaccessible jungle areas and water surfaces. Adult insects are killed in the air, and larvicidal action is obtained after the material falls to the surface of the water. Excessive winds may blow the material out of the control area; for that reason it may be desirable to distribute DDT during the windless portion of the day. Dusts and smokes are particularly susceptible to very slight wind currents. Dusts and emulsions are blown aside on water surfaces less than are oily solutions of DDT.

(c) Temperature. - Heat currents from the hot ground may carry fine sprays, dust, and smoke skyward, requiring application in the cool of the night or early morning. Most insects appear to be more susceptible to DDT in cool weather.

(d) Vegetation. - When deposited on vegetation, DDT possesses residual action against insects. Most green leaves rapidly absorb and carry away oily solutions, however. Vegetation also tends to protect larvicidal material, such as dusts, preventing the wind from disrupting the uniform surface coverage. Larger amounts of a more dilute DDT solution are usually desirable, owing to the difficulty of obtaining uniform surface coverage initially. Contrary to first expectations, fine sprays from airplanes are effective in penetrating dense jungle undergrowth. Sprays, dusts, and smokes will kill larvae breeding in water collections formed in the tops of certain trees, such as bromeliads, coconut fronds, screw (Pandanus) palms, etc.

(e) Washing. - Bulkheads, screens, and other surfaces treated with liquid or dust forms of DDT for residual effect should not be washed unless absolutely necessary. Surfaces washed or repeatedly wet will require more frequent application of DDT.

(f) Dust will cover up and render ineffective a DDT treated surface, as will fly droppings.

6. Devices for the Application of DDT.

(a) General. - The specific methods suggested for the use of DDT against particular insects (see Section 3 below) are based upon experiments in which equipment available in the field was utilized. Five principal devices for the applica-

tion of DDT have been studied: Nozzles, sprayers, dusters, aircraft dispersal equipment, and fog generators.

(b) Nozzles. - Nozzles may be adapted for use against adult insects, for larviciding, or for obtaining a residual effect from DDT on solid surfaces.

(1) In the use of DDT against adult insects in the air, the best results may be obtained with a nozzle producing a very fine fog-like spray. The whirler type nozzle with a very small hole (60 gauge or smaller) in the disc is well adapted to this use. The 60 or 56 gauge represents a nozzle opening of about 3/64 of an inch. The double-head nozzle with which the decontamination sprayer is ordinarily supplied has been found to be absolutely unsatisfactory.

(2) For larviciding a semi-fine spray is required; if the spray is too fine the material may be blown away. Disc-whirler type nozzles now available in the field are well suited to the purposes of larviciding.

(3) In obtaining the residual effect of DDT on solid surfaces, a semi-coarse spray with the least possible amount of mist or fog is needed, producing a moist but not soaking wet surface. The nozzle should be held 4 to 8 inches from the surface which is being treated. Application should be made in such a way as to leave 0.1 to 0.2 of a gram of DDT per square foot (2 to 4 cc. of a 5 percent solution or emulsion). At these rates 1 quart of 5 percent DDT solution is adequate for 250 to 500 square feet of surface. The residual effect of DDT will continue to kill insects which alight on the treated surface for many weeks or months, depending on weathering, rain, washing, dust, etc. On surfaces where staining by oil would be objectionable, the emulsion is best suited for obtaining a residual effect; kerosene and oils of low viscosity give almost as good results. A satisfactory residual effect can be expected from spraying nearly any type of surface-wood, glass, paper, cloth, or metal --but leaves and freshly painted wood will not give good results. Native habitations which house reservoirs of infection should receive special attention. The treatment of screening is very effective; this is most economically accomplished by painting the insecticide on screen surfaces with a brush. All surfaces of prefabricated structures -- heads, operating rooms, etc. -- may be treated before reaching operational areas; both inside and outside surfaces should be covered. Inside surfaces of all canvas tents and tarpaulins, bed nets, and jungle hammocks should be sprayed. Spraying bivouac areas for the residual effect of DDT need

not be delayed until tents and buildings have been erected; the application of semicoarse sprays to tree trunks, vegetation, and dead leaves imparts excellent and prolonged insecticidal action. The spraying of the ground itself is effective, particularly where insects are known to congregate, such as in dugouts and around gun emplacements, straddle trenches, heads, galleys, garbage pits, etc. Heavy rains diminish residual action, but light rains interfere only slightly.

(c) Sprayers. - Both the knapsack and the decontamination sprayers develop pressures adequate for dispersing DDT. The knapsack sprayer tends to spill oil on the skin of the operator; it should be used only in an emergency and then only half filled. The three quart hand sprayer is highly recommended for larviciding puddles, road ruts, and small scattered bodies of water, using 5 percent DDT. Hand sprayers of the "Flit-gun" type may be used in small scale work. Paint sprayers, hand or power operated, give excellent results. Sprayers in which emulsions are used are subject to more rapid rust and corrosion than those in which oils are used; if a sprayer is not to be used for several days, it should be dried out and oiled. Ordinary rubber washers, gaskets, and tubing deteriorate rapidly in contact with oils and other solvents, but DDT does not appear to increase this destructive action.

(d) Duster. - Any dispenser which produces a fine dust may be utilized. The hand pump duster is used for louse control, the rotary duster for large area control. Large amounts of dust may be distributed by a rotary duster. A large area can be covered in a short time. The plunger type duster, fitted with a flat nozzle, is well suited to the penetration of cracks and other places difficult of access, and may be employed for interior dusting against roaches, bedbugs, fleas, etc. Both shakers and blowers are used for treatment of rat runs and burrows against fleas.

(e) Airplane Dissemination. - Special equipment is required for either large or small planes. Solutions, dusts, and smokes have all been used; a diesel oil solution dispersed as a spray has been most widely used, and to date has been the most satisfactory. One to 2 quarts of 5 per cent solution (smaller amounts of 10 to 20 per cent solution) are required per acre for larval control; up to 3 quarts may be required for the control of adult insects. Area control during the critical phases of military operations may be accomplished most rapidly by this means. This method may prove to be the most economical for peace time control where areas are large

and inaccessible from the ground. It tends to be wasteful because so much solution falls on dry ground.

(f) Approval Required Prior to Use of Aircraft in Insecticide Dispersal Operations (Continental U. S.) - CNO Ltr., Op-55R-6-JLH: jk, SER. 47P55R, DTD 18 Nov. 1946; N.D. Bul. of 30 Nov. 1946, 46-2182, entitled "Large-Scale Dispersal of Insecticides, Justification for" provides that all requests for approval of aircraft dispersal of DDT should be forwarded to the Deputy Chief of Naval Operations (Air) via BuMed. Control of insects in areas adjacent to naval reservations are the responsibility of the U. S. Public Health Service. Naval aircraft will not be approved for spraying over civilian areas except in an emergency, if used solely for the protection of civilians. However, approval may be obtained where it is necessary to treat areas adjacent to naval activities in order to obtain protection for naval personnel. Where it becomes necessary to do such spraying, the district U. S. Public Health Representative shall be contacted for clearance and permission from all property owners concerned. Approval requests should contain location, size, description of area, typesoof vegetation, weather conditions, average wind velocity, maps, data on the nature and magnitude of insect problems present, importance in disease transmission, possible damage to animal or plant life, feasibility of ground control measures, and availability of aircraft and experienced pilots.

Contacts should be made with nearest representatives of the U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine; U. S. Public Health Service; State Health Department, local health authorities; State Entomologist; and the Fish and Wildlife Service as allied interested organizations.

(g) Fog Generators. - Fog generators mounted on trucks or trailers have been used with considerable success in the control of mosquito larvae and adults where areas are accessible to motor vehicles. The fog, consisting of droplets of insecticide 10 to 50 microns in diameter, drifts with slight wind currents into heavy undergrowth and vegetation, reaching distances from 200 ft. to 1/4 mile. It should be used when the air currents are descending rather than rising, for example when the ground is cool in the evening, night or early morning, in order to obtain best results. When terrain permits the use of a truck (or possibly a boat,) this equipment offers the best solution to the problem of large area coverage with small crews on the ground in a short period of time. Two types of large size generators are in current use, the Besler generator which utilizes steam pressure for dispersal, and the Todd generator

which disperses the aerosol (fog) by hot air blast. The cost of each type is in the range of $1,600.00 and the weight is upwards of five hundred pounds without the insecticide. Their maximum output is 40 gallons of insecticide solution per hour. One or more oil drums are usually used as an insecticide tank.

(h) Exhaust Aerosol Generators for Jeep or Weasel. - A few experimental units have been issued, utilizing the exhaust of a jeep or weasel motor for dispersing the insecticide into fog-sized droplets. This equipment is very simple, but it has low capacity, - 6 gallons per hour, - and requires racing of the jeep engine, which is hard on the engine and usually on the clutch as well. New units are not available at present.

Section III.--THE USE OF DDT AGAINST PARTICULAR INSECTS

7. Powerful action on the insect nervous system results from the absorption of DDT through the chemotactic sensorial organs in the tips of the tarsi and from other body surfaces. A short time after exposure insects drag their legs, their movements become poorly coordinated, and they finally develop tremors and convulsions followed by death. DDT does not repel insects, but after obtaining a lethal dosage, either from the air or from residual particles of DDT on surfaces, insects become restless and attempt to escape. Thus it is possible that the dead insects may not be found in the areas treated with DDT. Experiments have shown that insects trapped in the act of escaping from treated areas died within two to twelve hours. DDT does not possess the quick "knock-down" properties of pyrethrum; its lethal effect, however, is even more certain than that of pyrethrum. Another very distinct advantage of DDT over other insecticides is its versatile action against nearly all insects. It is highly effective against adult mosquitoes and mosquito larvae, flies, bedbugs, and lice; its effectiveness against roaches is somewhat less, but satisfactory and it is relatively ineffective against such arthropods as mites, spiders, ticks, and centipedes.

8. Against Adult Mosquitoes.

(a) Five per cent DDT in kerosene, light oil, or emulsion, when sprayed as a mist at a rate of 1 quart per acre, has given from 90 to 99 per cent control against adult mosquitoes within one hour. A large area surrounding the control site must also be treated if mosquitoes are not to infiltrate the site; with high pressure sprayers and finely atomizing nozzles, spray will drift several hundred feet; such areas have been kept free of

mosquitoes for several days following a single thorough treatment. Variables of sprayer pressure, nozzle size, and ventilation preclude specific dosage recommendations for spraying in closed spaces. Relatively small amounts are adequate.

(b) Area treatment with dust has been tried in an effort to control adult mosquitoes, but the results have been erratic and, in general, inferior to treatment with sprays. When dust is used, the recommended dosage is one in which 0.1 to 0.5 of a pound of active ingredient is applied per acre. Under adverse conditions, such as the presence of heavy vegetation and a strong wind, twice this dosage may be required.

(c) Inside buildings,1 to 6 seconds of spraying with an aerosol bomb is adequate for 1,000 cubic feet. Fog generators are very effective in clearing large outdoor areas of mosquitoes and flies in a short space of time.

(d) The residual effect of DDT on surfaces is best obtained by solutions or emulsions. An unscreened barn in Arkansas was treated with .022 of a gram of DDT (in kerosene solution) per square foot. Hundreds of dead mosquitoes were found after the first night; over 50,000 were found after the second night. It is not known how many flew out the open doors and died elsewhere; all of those trapped in the act of escaping died in less than 24 hours. Heavier application of the solution (0.1 to 0.2 of a gram per square foot) gives a residual lethal effect persisting for weeks and is the recommended dosage. Experiments indicate that the emulsion is equally effective. The residual effect with dusts is less pronounced, and aerosols, owing to their fine dispersal, possess minimal residual effectiveness.

9. Against Mosquito Larvae. -

(a) Unlike Paris Green, DDT is effective against both culicine and anopheline larvae. Culicines are much less susceptible, however. Five (5) per cent DDT in kerosene or oil (Diesel, lubricating, or crank-case) is the form most widely used in the field. Oil, when used alone, is required in amounts of 15 to 30 gallons per acre; the 5 per cent DDT solution, in amounts of 1 to 2 quarts per acre, is usually adequate for from 6 to 9 days' control. Since most ground equipment disperses 1 to 2 gallons per acre, a 1/2 to 1 per cent DDT solution is adequate, when so used. More concentrated doses may be necessary, depending upon overflow, rain and vegetation. Sewage and mud increases the amount of DDT needed. Because of these variables, weekly larval counts are necessary as a check. Prolonged effectiveness up to three to four weeks may be obtained with doses containing 0.5 to 1.0 pound of DDT per acre (5 to 10 quarts of the 5 per cent solution.) But except in

combat or in other critical situations, these heavy doses are wasteful, unwarranted, and dangerous to fish and wildlife. DDT does not increase the spreading properties of oil. Best results are obtained through applying the oil as a semi-fine spray, utilizing wind drift for reaching inaccessible water surfaces. Results are much poorer when solutions are poured on the water surface from one point or are soaked in sawdust and sown. Drip cans are not satisfactory, since the valve tends to clog as a result of the DDT's precipitating out at the opening. Heavy doses of DDT will kill fish and other aquatic life. Concentrations in excess of 1 part in 10,000,000 are lethal to fish; excessive dosage on water or vegetation may also be harmful to domestic animals. Detailed information will be found in a CNO letter to all continental stations.

(b) Emulsions may also be used for larviciding; they are not blown aside on the water surface to the same extent as is oil. A somewhat heavier dosage of DDT is required, however, if the emulsion is used, since the emulsion penetrates to the depths of the water whereas oil solutions float on the surface. For this reason the emulsion is not recommended for larviciding unless a saving in transportation is essential.

(c) It is difficult to spread evenly 1 pound of 10 percent dust over an area of 1 acre (0.1 pound DDT.) Accordingly, it should be thoroughly mixed with 5 to 10 parts of fine road dust, condemned flour, or any other inert diluent which is easily dispersed, and distributed at the prescribed rate. In critical areas larger doses up to 0.5 of a pound or more of DDT per acre may be required. Owing to the large size of the particles of commercially pure DDT, it cannot be effectively mixed with diluent dusts in the field. It is necessary, therefore, to use the 10 percent dust as the basic component for mixture with additional inert material.

10. Against Flies. -

(a) The potentialities of DDT against flies were first fully realized through an accident which occurred at a testing laboratory: DDT was being mixed with dust, and nearly all of the flies in a large experimental cage several hundred feet from the mixer were killed.

(b) Emulsions and oil or kerosene solutions, when sprayed in a fine form, will kill flies very efficiently. Lethal action is certain, though it may be somewhat delayed. About 30 to 45 minutes, or even longer, may be required before flies show signs of being affected.

(c) Dusts are very effective in killing flies. A pound of DDT in dust was dispersed as a roachicide in a store. Fol-

lowing this single application the owner did not find it necessary to spray against flies for two weeks; previously, standard fly spray was required several times daily. For the most effective results, a relatively light dusting about heads, garbage racks, etc., is recommended.

(d) The residual action of DDT against flies is by far the most efficient. DDT should be applied to surfaces on which flies are accustomed to alight, such as heads, ceilings, light coards, screens, garbage racks, etc. Two (2) to 4 cubic centimeters of 5 per cent solution per square foot (1 quart to from 250 to 500 square feet) are adequate for prolonged effect. A single spraying of a 1 per cent solution rendered a barn which had previously been heavily infested practically free of flies for 36 days. If flies are numerous, they will shorten the effective life of a DDT residual application.

11. Against Bedbugs. -

When properly applied, DDT will keep mattresses free of bedbugs for six months or more. The 5 per cent kerosene spray or the emulsion is recommended. An experiment using about 250 cc. per bed, including mattress, pillow, springs, and bedframe, killed all the bugs present; bugs experimentally reintroduced four to ten months later were also killed. Three and one-half (31/2) gallons of 5 per cent solution are adequate for a 70-man barracks. The recommended technique for barracks or ships is as follows:

(a) All clothing, rubber material (such as gas masks,) and other objects to be protected from kerosene should be covered or removed from the spaces to be treated. Smoking should be prohibited and all flames extinguished.

(b) Workers should wear filter type or moistened, fine-gauze masks over the nose and mouth. Most of the windows or ports should be closed so that droplets will fall on exposed walls and other surfaces, thus adding to the desired residual effect. If xylene emulsion is used, ventilation should be quite free, because of the explosive hazard of xylene fumes.

(c) Mattresses should be placed in piles of 8 to 10 each. If movable, bunks should be placed on end around the sides of the room so that excess spray will fall on the walls.

(d) A semi-fine spray is best; too fine a spray is wasteful and ineffective. A powered paint sprayer gives the best results; the nozzle should be adjusted so that a brush-shaped spray is formed.

(e) The outside surfaces of the pile of mattresses should be sprayed first. One man operating the sprayer should then apply the solution to one side of the top mattress; his assistant should quickly turn it over to be treated on the other side and

then move the first mattress away while the sprayer begins on the second. A slight moistening of the surface is all that is required. A few minutes after application, the kerosene will have partly evaporated, leaving visible small glistening DDT crystals adherene to the surface. Pillows should be treated in a similar manner.

(f) Next, the springs and bedframes should be given a quick spraying, with the spray directed toward walls and bulkheads in order that excess material may be deposited on them. Direct spraying of these surfaces is then unnecessary.

(g) At first there will be a tendency to use excessive amounts of the insecticide. A trial run on a few mattresses will indicate whether the right amounts are being used.

(h) Shortly after the spraying is completed all sizeable droplets will have adhered to the wall or floor surfaces, and all the windows or ports should then be opened. The mattresses should be returned to the beds, and may be used after four hours. When the steps outlined above have been taken, all bedbugs on the bed will be killed within 24 hours; bugs introduced up to six months later will be killed. It is unnecessary to give special treatment to walls and cracks, since the insects will obtain a lethal dose when they go from their habitat in the wall, or other place, to the bed for a blood meal. It may be necessary to spray blankets and the insides of barracks bags; canvas cots should always be treated. When upholstered furniture or other padded objects are treated for bedbugs, the emulsion of DDT should be used because it leaves no oil stain. Smoking should be prohibited for atleast six hours, preferably twelve, because of the fire hazard.

12. Against Body Lice. -

(a) DDT has made possible the effective control of louse-borne typhus. Extensive experience in louse control in North Africa and Italy has shown that 10 per cent DDT dust is by far the best method of louse control available, and usually the simplest and most economical as well.

(b) Underclothing properly impregnated with DDT prevents louse infestation for about two months or until washed eight times. Clothing impregnated with an aqueous emulsion of DDT, if available, can be issued after bathing and dusting (delousing) of the individual or put on prior to exposure to the danger of louse infestation. Clothing can be impreganted with a 2% aqueous emulsion of DDT usually made up as follows: Add 11 gallons of water to each gallon of insecticide concentrate solution (DDT-xylene-emulsifying agent Stock Number 51-1-157-500.) The water is added slowly to the concentrate

with constant stirring. After soaking the clothing in the 2% aqueous emulsion, it is moderately wrung out by passage through a wringer and allowed to dry completely before wearing.

(1) A Lyster bag (which should not be used for drinking water afterwards) is well suited for the dipping, its 30 gallon capacity being adequate for 125 suits of two piece (50% wool) underwear. The emulsion does not affect the rubber lining of this bag or the rubber rollers of a wringer. Tongs or other means for dipping and wringing the clothing should be used, rather than the bare hands.

(2) The concentrate (Stock Number 51-I-157-500) contains 25% DDT or 8 oz. per gallon. The DDT concentrate of the emulsion is roughly calculated to result in impregnation of the clothing with an amount of DDT equal to 1.5-2.0% of the weight of the clothing.

(c) Delousing Powder in 2 ounce tins (10% DDT Stock Number 51-I-171) can be applied by hand with its sifter container, by a plunger type of hand duster (Stock Number 41-D-4510, Duster, Insect, Powder, Plunger Type, Hand Operated), or if available, a compressed air powder duster, to the clothes and body of the individual. If necessary, a sifter can easily be made by punching one or more rows of small holes parallel to and close to the bottom in the wall of a cylindrical can of a diameter not exceeding 31/2 inches. The duster operates best when the reservior is three quarters (3/4) full. About one ounce of the powder is necessary for each person and his clothes; 4 to 6 ounces if bedding and equipment are included. The clothes on the person need not be removed for dusting, except when dusting by hand. Ten per cent (10%) DDT Delousing Powder kills lice by oontact within 8 hours and prevents re-infestation for 3 to 4 weeks, killing the lice as they are introduced into the dusted clothing. Dusted clothing and equipment, if laundered or washed, <u>cannot</u> be depended upon to protect against louse infestation. A systematic routine is employed to avoid neglecting any part of the person's body and clothing as follows:

(1) Powder person's head and inside of hat.

(2) Insert nozzle of duster between skin and innermost layer of underwear or clothing and blow dust up each sleeve, around collar, down front and back of chest,

around waist, and down trouser legs after loosening trouser belt.

(3) It is essential to have the entire innermost surface of garments covered with a layer of dust, especially the folds and seams. Powder should be visible on body hairs of chest, thighs, armpits, pubic, perineal, and head regions. Examine clothing and body of first few persons dusted to check the results.

(4) Dusting of removed clothing by hand must accomplish the results described in the previous paragraph.

(5) To dust equipment properly, all surfaces, seams, folds, corners, etc., are dusted with the powder.

13. Against Crab and Head Lice.

Ten per cent (10%) DDT Delousing Powder is effective in the treatment of head and crab louse infestation. It must be applied to the infested hairy portions of the body twice with an interval of 7 to 10 days between applications. The dust must not be washed off for at least 48 hours. The second application kills the larvae hatched from the eggs which were not harmed by the first treatment, and is essential for complete destruction of the lice.

14. Against Fleas.

(a) Ten percent (10%) DDT in talc or pyrophyllite is recommended for application to animals with fleas. The material should be rubbed or blown into the fur. DDT should not be used on cats, as they may lick off enough to poison them. Oily solutions and emulsions are not recommended, since in these forms DDT is absorbed in toxic doses. In the control of plague, the dust should be blown into spaces infested with fleas or rats, preferably before starting to kill the rats. The dust will kill any fleas in the burrows, as well as those leaving the carcasses of rats which have succumbed to the disease; if fairly heavy doses are used, rats will deflea themselves, with the DDT that clings to their paws.,

(b) Five percent (5%) DDT in kerosene, oil, or emulsion will also kill fleas. The application to surfaces for residual action is effective. DDT in these forms must not be applied to the skin of animals or human beings.

15. Against Roaches.

All roaches are killed by adequate doses of DDT. The German roach (the light brown roach, one-half inch in length, common to the Southern United States) is more difficult to kill with DDT than are most insects. Other roaches, however are relatively easy to kill. Five (5%) percent DDT in kerosene,

oil, or emulsion kills roaches by residual action but heavy applications are usually needed. The material should be sprayed around pipes, on table legs, in cracks, and in other areas frequented by roaches. Ten (10) per cent DDT in talc, as supplied in bulk, should not be diluted, since the 10 per cent strength is required against roaches when dust is used. It should be generously applied to cracks and other points inhabited by roaches. The practice of spraying followed immediately by dusting while the surface is wet, will usually give the most satisfactory roach control.

16. Against Mites (including Chiggers.)

The delayed action of DDT makes the 10 per cent powder ineffectual as a preventive against tsutsugamushi fever (scrub typhus). Repellents, such as dimethyl phthalate, are more efficient against mites.

17. Against Spiders, Ticks, and Centipedes. - DDT may not be depended upon to kill these arthropods, although it is effective against ticks on dogs, about kennels and in houses.

Section IV.--THE TOXICITY OF DDT TO HUMAN BEINGS

18. When employed only in the effective insecticidal dosages, DDT is definitely less toxic to man than Paris green, sodium fluoride, lethane, or thanite.

19. Action on the Skin.

Experiments with animals have shown that there is no absorption of dry DDT powder from the skin, but oily solutions are absorbed, large doses causing hyperexicitability, tremors, clonic convulsions, and liver damage. Men engaged in mixing or spraying the oily solutions of DDT should take all necessary precautions toprevent the material from spilling on or coming in contact with the skin. Occasional contact is apparently not dangerous but repeated or prolonged contact must be avoided. If accidentally spilled on the skin, wash immediately with soap and water. It is for this reason that the decontamination type of sprayer is preferable to the knapsack type, which should be used only in an emergency and then only half-filled.

20. Parenteral Absorption.

In animals, dry DDT is not readily absorbed when injected intramuscularly or subcutaneously. In oils, however, it acts in the same manner as when absorbed in oily solution from the skin.

21. Effect on the Nervous System.

The acute toxic manifestations in animals consist of an-

orexia, irritability, tremors, convulsions, and paralysis. The effect on the nerve tissues is apparently purely functional, there being no demonstrable pathological lesions in the brain, spinal cord, or peripheral nerves.

22. Effect on the Respiratory Tract.

No toxic symptoms occurred in dogs and rats exposed in an atmosphere containing many times the recommended insecticidal concentration of DDT in aerosol. Daily exposure of monkeys and men for one hour to heavy concentrations of DDT in dust caused no ill effects. The talc or pyrophyllite contained in 10 per cent DDT powder offers no apparent threat of silicosis; this danger is present, however, among men constantly exposed, week after week, to heavy concentrations. A respirator should always be worn when applying any insecticidal dust within closed spaces. The toxicity from the inhalation of heavy concentrations of DDT smokes has not been definitely determined, but it is probably no greater than that of similar exposure to sprays.

23. Effect on the Gastro-Intestinal Tract.

One hundred (100) mgs. of DDT per kilogram per day, by mouth, produced no toxic effects in animals. Two hundred (200) mgs. per kilogram per day killed 90 per cent of the test animals. They showed tremors, convulsions, incoordination, prolonged prothrombin time, toxic necrosis of the liver, and a terminal nephritic picture. Such a dose is many times that an individual would obtain when carefully dispersing the recommended insecticidal quantities of DDT. The occasional ingestion of water which has been treated for larvicidal action is apparently not harmful, but this must be avoided wherever possible.

24. Toxicity of DDT Solvents.

The use of halogenated hydrocarbons as solvents for DDT must be avoided. Tetrachlorethane and carbon tetrachloride, which are powerful liver poisons, are the most dangerous members of this group. Trichlorethylene is the least toxic of the commonly used solvents of this group. The inhalation of large doses of kerosene (containing no DDT) dispersed in closed spaces will produce tracheitis, mental confusion and mania; deaths have occurred from a very heavy dosage of kerosene. The xylene contained in DDT emulsion produces conjunctival pharyngeal and tracheal irritation when dispersed in closed spaces. Cyclohexanone, which is frequently used as a solvent for DDT, in heavy concentration produces a harmless, temporary irritation of the eyes, nose, and lungs, In extremely heavy doses it possesses a depressant action on the central nervous system.

25. Conclusions.

In galleys, DDT should be used only under those conditions which exclude the massive contamination of food. Foods and cooking utensils must be thoroughly covered. DDT is tasteless and bears a physical resemblance to flour; it must not be stored near food supplies. Although oily solutions are absorbed from the skin, a 5 per cent solution may be safely used if reasonable precautions are taken to prevent contact. Other non-volatile solvents, such as used in repellents, may also act as vehicles from which absorption of DDT powder through the skin is made possible; DDT powder must not, therefore, be applied to areas of the skin on which repellents are to be used. The 10 per cent powder is safe, but personnel engaged in mixing dusts should wear a respirator or a moist cloth over the nose and mouth during the mixing process. This is not necessary, however, when dispersing the dust, if care is taken to disperse it to the leeward.

Section V.--INSECT CONTROL MEASURES

SANDFLIES (Moth Midges, Phlebotomus)

Importance: Bite transmits sandfly fever (phlebotomus fever), Leishmaniasis, Bartonellosis. Also nuisance.

Description: Small gnats 1 to 5 mm. long, wings and body covered with hairs, wings held at an angle of about 45°, females bloodsucking.

Habits: Breed in crevices of cement, rocks, soil, boards, moist rubbish, sandbags, cesspools, dead trees, etc. Adults have a short flight range, bite nocturnally, and are attracted to lights.

Protection of Personnel: Use of fine mesh screening (No. 18 mesh will not exclude them), oiling of screening with lube oil, treating of screening with 5 percent DDT, standard repellants on skin. Wearing of protective clothing after sundown. Repellants on wide mesh netting.

Eradication of Breeding: Disposal of rubbish, rock piles, and delapidated cement structures. Spraying of 5 percent DDT on breeding surfaces which cannot be aired or disposed of (1 part creosote to 4 parts diesel oil may be used). Drainage and harrowing of breeding points in damp soil.

Destruction of Adults: Aerosol bomb(6 seconds' spraying per 1,000 cubic feet), residual DDT applied to solid surfaces throughout camp area provides an insecticidal barrier.

SALT MARSH SANDFLIES (No-See-Ums, Biting Midges, Culicoides)

Importance: Nuisance.

Description: Small, slender gnats 1 to 3, and rarely over 2 1/4 mm. long; females bloodsucking.

Habits: Breed in wet sand and mud around ponds, streams, and swamps (either fresh or salt water). Adults have flight range up to 1 mile; day and night biters; attracted to lights.

Protection of Personnel: Same as for sandflies.

Eradication of Breeding: Drainage of areas having ddcaying humus. DDT not very effective.

Destruction of Adults: Same as for sandflies.

EYE GNATS (Hippelàtes)

Importance: Transmit by contact a moderately severe form of conjunctivitis. Nuisance.

Description: Small gnats 2 to 3 mm. long; non-bloodsucking.

Habits: Breed in moist soil containing excreta, decaying vegetableor animal matter.

Protection of Personnel: Same as for sandflies.

Eradication of Breeding; Cleaning up of decaying vegetable or animal matter. Proper disposal of human excreta. Plowing or harrowing of soil to produce drying of soil and exposure of larvae to hot sun or cold air

BUFFALO GNATS (Black Flies; Simuliidae)

Importance: Transmit Onchocerciasis. Nuisance.

Description: Small gnats 1 to 5 mm. long, stout bodies, humpbacked appearance, wings broad and irridescent; females bloodsucking.

Habits: Breed in rapidly running streams (larvae attached to rocks); some species breed in swampy areas (immature stages attached to overhanging limbs which touch the water).

Protection of Personnel: Same as for sandflies.

Eradication of Breeding: No method satisfactory. Clearing streams of debris and overhanging branches. DDT has been effective experimentally.

Destruction of Adults: Same as for sandflies. Fog generators with DDT.

HOUSEFLIES

Importance: Contact spread of dysentery , yaws, cholera, poliomyelitis (P.).

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Description: Dull bodies, about 6-7 mm. long, 1 pair of wings; 13-15 mm. across the wings.

Habits: Breed in organic matter (feces, garbage, grease-soaked soil, decaying bodies, blood.) Requires 5 to 14 days from eggs to adults. Larvae migrate into soil, then become pupae which are immobile (resemble a capsule.) Adults live for year or more; attracted to odors of food or decaying protein. Tend to rest on walls, rafters, light cords, screens; attempt to escape from buildings or fly-traps through sun-lit windows or surfaces.

Protection of personnel: Deny flies access to food by use of screens, netting, wrapping, etc.; galleys should not be allowed to operate unless this is possible (field rations should be used). If flies are unavoidably present food should be served steaming hot. Deny flies access to human excreta and other sources of infection by screening of heads, flyproofing latrine boxes, etc.

Eradication of breeding: Deny flies access to feces, garbage, and other breeding media; open straddle trenches and garbage pits should be frequently covered by dirt or sprayed with oil. *Paradichlorobenzene* vapor kills fly larvae and repels adult flies from the source of infection and breeding points. When deposited in straddle trenches or boxed-in pits it slowly vaporizes, the heavy vapor remaining in the pit. Use 1 pound for each seat, with one-fourth pound twice weekly subsequently. Vaporization does not occur if P.D.B. is covered by water or feces. Penite (sodium arsenate) - spraying of 1 percent water solution of sodium arsenate kills fly larvae. Surfaces of corpses, garbage, greasy earth, etc., should be thoroughly wetted. DDT - High dosages required for control of fly larvae.

Destruction of adults: Residual spray highly effective (See ''Flies'' in DDT section.) *Pyrethrum* quickly knocks flies down; they may recover if small doses are used. Not as effective as against mosquitoes. *Aerosol bomb* - containing DDT very effective in semi-closed spaces; may require several hours before death ensues; 6 seconds spraying required for 1,000 cubic feet. *Liquid insecticide* used as a mist spray is effective knock-down and killing agent. *Fly-traps* properly baited and located about areas where flies congregate may reduce total population. Out-moded by DDT. *Fly-paper* - Formula: Heat powdered resin, 8 parts, and castor oil, 5 parts (by weight); stir well while heating; the mixture should not come to a boil. In hot weather the proportion of resin should be increased. Sugar or honey may be added, but not essential. The fluid is spread while hot over glazed paper. The mixture may be painted on iron hoops or wire strands. Wires so painted should be cleaned and recoated every 2 or 3 days.

STABLEFLIES (Dogflies)

Importance: Bites severely painful. In certain coastal areas these flies may preclude outdoor activity.

Description: Resemble houseflies but have piercing mouth parts; bloodsucking.

Habits: Breed in turtle or eel grass washed ashore on beaches of sounds or basins, in decaying hay, waste cattle feed, and in litter left in fields where celery, peanuts, etc., are grown.

Protection of personnel: Screening. Repellants are helpful. Navy repellants contain indalone, 20 percent, for this purpose. Repellancy lasts from 3 to 7 hours.

Eradication of breeding: Five percent DDT solution sprayed over breeding areas prevents breeding. A spray consisting of 3 parts kerosene and 1 part creosote is less effective than 5 percent DDT. Decaying hay and manure containing hay should be thinly spread, the drying effect will prevent breeding.

Destruction of adults: Residual application of DDT to animals. Spraying, trapping, swatting, and other measures outlined under ''Houseflies''.

BODY LICE (Pediculus Corporus)

Importance: Fecal material transmits epidemic typhus. Bite transmits relapsing fever and trench fever. Diseases also transmitted by rubbing crushed lice on skin.

Description: 2 to 3 mm. long; usually gray; bloodsucking.

Habits: Breed in seams of clothing, folds of mattresses, in body hair. Newly hatched larvae die unless they feed within 25 hours. Development from eggs to adults requires 17 to 20 days. Adults - Females lay 5 to 10 eggs per day for 30 days. Attracted to warm parts of clothing; hide under seams where they lay most of their eggs; prefer woolen clothing. Bite humans for blood meal. The egg or nit hatches in about 8 days at body temperature, but may require several weeks at lower temperatures.

Protection of personnel: Avoidance of contact with louse-infected individual or material (e.g. clothing, bedding, etc.). Personal cleanliness (at least weekly bathing with soap and water and clothing changes, particularly underclothing). Avoidance of overcrowding. Instruction and education of men on prevention of louse infestation. Use of DDT. Inspection (at least weekly) of body and clothing for lice. (See ch. 9, sec. III.)

Eradication of breeding: See chapter 9, section III.

Destruction of adults: Louse powder containing 10 percent DDT contact for 8 hours. Does not destroy eggs, but as larvae hatch they are killed. Dry heat and live steam. Starvation of lice -

storage of dry clothing in dry place for 21 days in warm or 30 to 40 days in cold weather. Methyl bromide fumigant (see ch. 11). *Note.* Rickettsiae, the causative agents of typhus fevers and the spirochete causing relapsing fever are not destroyed by contact with DDT or methyl bromide. The clothes and equipment of patients afflicted with epidemic typhus fever, relapsing fever, or other louse-borne disease must be sterilized or otherwise treated to insure destruction of the etiological organism as well as the lice. (See ch. 9, sec. III)

PUBIC LICE (Phthirius pubis) "Crabs"

Importance: Nuisance.

Description: 1.5 to 2 mm. long, nearly as broad as long; crablike appearance.

Habits: Breed among pubic, gluteal, and thigh hairs. Attach small white eggs to hairs; eggs hatch in 6 to 8 days. Adults cling to hairs and descend to skin for blood meals.

Protection of personnel: Thorough scrubbing of toilet seats removes lice left by infected individual. Avoid wearing unwashed clothing of other individuals. Properly administered prophylactic kills lice contracted during sexual relations with infested individuals.

Eradication of breeding: Early diagnosis and treatment is extremely important. The occurrence of cases warrants inspection of all personnel in the unit. Clothing of infested individual should be laundered before being worn again. Toilet seats should be scrubbed at least once, preferably twice daily.

Destruction of adults: 10 percent DDT powder kills adults but does not destroy eggs, this requires a second treatment 6 days after initial treatment. Louse powder containing pyrethrum (MYL powder) kills both adults and eggs in one treatment.

TICKS

Importance: Transmit Rocky Mountain spotted fever, relapsing fever, boutonneuse fever, ''Q'' fever, and cause ''tick paralysis.''

Description: Rarely exceed 15mm., flat and leathery before feeding; immature ticks have three pairs of legs, adults have four pairs; usually become distended and sacklike when engorged with blood.

Habits: Ticks cling to bushes, leaves, and grass and attach themselves to animals or humans for blood meal. Take 1 or 2 hours to become attached but remain attached for several days to a week or more.

Protection of personnel: Clothing - Button collar; wear high shoes or leggings and tuck trousers inside of socks. Never sleep in clothing worn outdoors. DMP or other repellants may not be depended on. Inspection - Personnel should pair off and inspect each other every

4 hours. Remove ricks by gentle traction; application of chloroform, kerosene, repellant, or lighted cigarette causes ticks to release grasp.

Eradication of breeding: Destroy mice, rats, and other small animals. In infested areas bar dogs and other animals from occupied area. Underbrush, grass, and weeds shomld be closely cut or burned.

4 hours. Remove ticks by gentle traction; application of chloroform, kerosene; repellant, or lighted cigarette causes ticks to release grasp.

Eradication of breeding: Destroy mice, rats, and other small animals. In infested areas bar dogs and other animals from occupied area. Underbrush, grass, and weeds should be closely cut or burned.

Destruction of adults: DDT may not be depended upon to kill ticks in area spraying. In treating buildings large doses are required. On animals 10 percent DDT dust should be rubbed into fur and excess brushed off (if animal licks sufficient quantities it may be poisoned) Cats should not be treated. Rotenone is more effective for use on animals. U. S. Department of Agriculture, in 1945, reported that 0.5 percent DDT and 2.5 percent soluble pine oil to vegetation. Three pounds per acre is effective against American dog tick.

MITES (Chiggers, Red Bugs, Betes Rouges)

Importance: Larvae transmit scrub typhus; also constitute a menace as skin irritant, lesions frequently become secondarily infected.

Description: Very small, less than 0.5 mm.; usually bright red.

Habits: Breed a few inches beneath the ground surface. Larvae climb on grass, bushes, etc., for opportunity to attach themselves to warm-blooded host. Adults do not feed on humans but return to debris to lay eggs.

Protection of personnel: Clothing and leggings provide some protection. Dimethylphthalate on skin protects for a few hours. Should be applied as a half inch circular barrier inside cuffs and front of shirt; may also be applied to clothing as ''wetting'' spray. Dimethylphthalate emulsion impregnation is preferred as it remains lethal to mites after 15 minutes in running water. This emulsion is composed of water 92 percent; D.M.P., 5 percent; and soap, 3 percent. 1.5 quarts of emulsion is required for each uniform (including socks). Allow clothing to dry before wearing. Do not treat shorts as it will cause scrotal irritation.

Eradication of breeding: Clear underbrush, vines, and bushes from area to be inhabited by troops, and burn or remove all debris; scrape off vegetation and surface dirt with bulldozers. Apply flowers of sulfur (325 mesh) to vegetation and ground with rotary duster at the

rate of 1 pound per 1,000 square feet (45 pounds per acre). Repeat weekly (or oftener if it rains). DDT is not very effective. Control rodent hosts.

Destruction of adults: Same as for ''Eradication for breeding.''

SCABIES MITES (Sarcoptes Scabiei Mites)

Importance: Cause scabies.

Description: Minute parasites barely visible to naked eye, appearing grayish in color.

Habits: Breed in skin burrows, eggs being laid between layers of epidermis where they hatch in 4 to 7 days. Adults burrow into skin where they feed on blood, lay eggs, then emerge several days later.

Protection of personnel: Cleanliness of body and clothing. Avoid interchange of clothing, bed linens, etc. Isolate individuals with scabies. The diagnosis of a case of scabies requires an inspection of all persons in the unit. Clothing and linens of patients must be boiled.

Eradication of breeding: Same as ''Protection of personnel.'' Medical treatment employs either benzylbenzoate or sulfur ointment.

Destruction of adults: Boiling or steaming of clothing and bed-destroys the parasites. Treatment of patient kills most of the adult mite population.

FLEAS

Importance: Bite transmits plague and murine typhus. The nuisance value of the bites may be very severe. Flea bites become infected.

Description: 1.5 to 4 mm. long, laterally compressed, wingless, bloodsucking.

Habits: Breed on animals and in their habitats. Adults cling to animals and humans where they suck blood. They also hide in clothing cracks in walls and floors, upholstery, under rugs, etc.

Protection of personnel: Clothing affords a barrier against fleas (the same as for mites). Repellants should be used in areas where flea-borne diseases are present. They should be used in the same manner on the skin and clothing as used against mosquitoes. DDT in clothing before exposure to fleas is good but not after fleas are in the clothing.

Eradication of breeding: Destroy rats and other small animals which harbor fleas. Treat infested domestic animals (except cats) with 10 percent DDT powder (rub into skin and brush off excess on outer coat of fur to prevent animal from licking it. Remove debris from vicinity of troops and burn it. Dust floors, furniture, and animal nests and burrows with 10 percent DDT or spray with DDT solution.

Destruction of adults: Residual spray of 5 percent DDT applied to floors, cracks, baseboards, animal habitats, etc. Application to the ground is effective if 1 gallon of 5 percent DDT is used for each 1,000 square feet, but effectiveness does not persist. Ten percent DDT dust in houses, on ground, and in rat holes is effective. Sprinling flea-infested floors with flakes naphthalene and closing the room for 24 hours is effective.

BEDBUGS

Importance: Nuisance.

Description: Adults are from 4 to 5 mm. long, and 3 mm. broad; flat oblong bodies, usually reddish brown, wingless, bloodsucking.

Habits: Breed in folds of mattresses, on protected points of bed frames, in bed clothes, clothes, in cracks on wall, etc. Adults emerge from hiding places at night to bite humans. May survive 6 months without food.

Protection of personnel: Inspect bedding of transferred personnel for bedbugs. Periodic bunk inspections should be made.

Eradication of breeding: Residual spray of 5 percent DDT in kerosene on mattresses, bed frames, and bulkheads provides eradication for 4 to 10 months (see ch. 9, sec. III). Pyrethrum and other sprays should be used only if DDT is not available.

Destruction of adults: Same as for ''Eradication of breeding.'' Bedbugs are killed by a temperature of 120 to 125 degrees F. when this temperature is maintained for a period of 24 hours. Mattresses and pillows may be run through sterilizer before being placed in store rooms.

ANTS

Importance: Nuisance.

Description: Varying in size from very small to 1 inch in length; usually wingless.

Habits: Breed in soil; excavated soil from cave forms ''ant hill.''

Protection of personnel: Repellants may protect against certain biting species.

Eradication of breeding: Deprive ants of food which attracts them to galleys, repair cracks and other defects in buildings, dig infested earth and burn over with kerosene, pour one of the following into the holes, 1 to 2 inches deep, around breeding areas: carbon disulfide, orthodichlorobenzene, or boiling water. *Caution.*- Carbon disulfide is highly explosive, keep away from sparks or flame.

Destruction of adults: Sodium arsenate mixed with bait, such as honey, sugar, lard, etc., may be used. DDT residual spray on surface traversed by ants is effective. Ten percent DDT powder sifted on surfaces traversed by ants is effective.

ROACHES

Importance: Nuisance around galleys and food storerooms.

Description: Up to 2 or 3 inches long; brown to black; two pairs of wings, when present outer pair leathery.

Habits: Live in dark recesses about pipes, under boxes and flooring; tend to come out at night to feed. General feeders with preference for starchy and sugary materials.

Protection of personnel: None.

Eradication of breeding: Treat accessible breeding areas with boiling water, kerosene, 5 percent DDT (in kerosene or in emulsion form), or 10 percent DDT dust. Remove all food scraps so that roaches will starve or go elsewhere. Make galleys roachproof - close cracks, crevices, and openings about pipes with putty, cement, plaster or wooden strips; keep galleys and storerooms dry and well ventilated.

Destruction of adults: Powders may be spread thinly about water pipes, under sinks and baseboards, in cracks and crevices. The following may be used: (1) sodium fluoride- most effective but very dangerous to humans. (2) 10 percent DDT dust- moderately effective (3) Powdered borax. Sprays are not removed by wind, sweeping, and washing as readily as powders; they also adhere to vertical surfaces. (4) 5 percent DDT in kerosene. (5) 5 percent DDT emulsion (see ch.9, sec. III).

Chapter 10

Mosquito Control

Section I.--THE DEVELOPMENT, HABITS, AND CHARACTERISTICS OF THE MOSQUITO

1. Mosquito borne diseases incapacitate large numbers of fighting personnel often during critical stages of military operations. Diseases such as malaria, dengue, filariasis, yellow fever, and others may be prevented by protecting the individuals from mosquito bites (this may also be effected by reducing or eliminating the mosquito population.) The life cycle and habits of the disease-bearing mosquito must be known before successful mosquito control measures can be effected. Since all species of mosquitoes are not disease vectors, and since various genera and species differ as to habits, it is important that the specific vector or vectors of the various mosquito borne diseases and their habits be well known in order that proper control can be accomplished.

2. Manner of Disease Transmission. - Fluid from the salivary glands, injected through the mouthparts of the female mosquito while feeding, is responsible for the introduction of parasites of malaria and the viruses, as well as local irritation. Filarial worms, waiting in the mouth parts, crawl onto the skin, and later burrow into it.

3. Life Cycle.

(a) Mosquitoes undergo complete metamorphosis. The female usually lays from 50 to 100 eggs at a time, varying in length from 0.5 to 2.0 mm., on or near water. Some species lay their eggs singly on the surface of the water; others stick them together in "rafts;" while still others place them in mud where they will hatch when flooded.

(b) The larvae of mosquitoes breathe through caudal air tubes which necessitates frequent contact with the surface of the water. This characteristic together with the tendency of

certain species to remain at the surface to feed, has made larval control possible through the use of larvicides applied to the surface of the water. So far as is known, there are four larval instars in all species of mosquitoes. With the fourth molt the larva becomes a pupa. The pupae like the larvae, are aquatic, but differ greatly in form. The head and thorax are greatly enlarged, not distinctly separated, while the abdomen remains slender and flexible. The breathing apparatus has moved forward to the thorax and consists of two tubes. No food is taken in this stage and they are thus more difficult to kill than the larvae.

(c) The change from larval characteristics to those of the adult takes place within the pupal shell, and requires two or three days. The pupal skin splits down the back and the winged adult works its way out, rests upon the surface film, while its wings dry, then flies away.

4. Time Required for Development. - The developmental time of the larval and pupal stages is of the greatest importance in timing the frequency of control measures needed to kill successive broods. The rate of development of various stages differs markedly among species and the rate is increased or decreased according to the climatic temperature and the availability of food. The average time required for development from egg to adult in the tropics is seven to ten days. Formerly, weekly applications of larvicides were usually required in such areas to assure continuous control, but with the advent of DDT, the frequency of applications has been reduced to from 10 days to two weeks with light applications. In cold climates, mosquitoes develop more slowly; they may spend the winter in any one of the life stages depending on the species. The life span of adults varies from a period of a few weeks to several months depending to some degree on the climate. It is clear, therefore, that the factor of difference in species and in climatic conditions must be carefully considered in all control measures.

5. Breeding Places. - Mosquito larvae develop only in the presence of water, but they are found under varying conditions such as in standing or running fresh or salt, clean or polluted water, in sunshine or in shade. Knowledge of the fact that most species are restricted to specific types of breeding places is helpful in conducting control measures.

6. Flight Range. - The flight range of disease-bearing mosquitoes determines the radius of antilarval control measures. Anophelines have a flight range of from one to two miles. If breeding is heavy, appreciable numbers will be found near the limit of their range, and the control area must be expanded

to such limits. The so-called domestic mosquitoes of the genus Aedes, which includes vectors of such diseases as yellow fever, dengue, filariasis, and Japanese B encephalitis develop primarily in artificial containers of water near human habitations and fly only a few hundred yards. At the opposite extreme, certain types of salt-marsh mosquitoes are known to fly distances of 40 miles or more with the aid of favorable winds.

7. Classification of Mosquitoes.

(a) Not all species of mosquitoes transmit disease and those that do are specific for certain diseases. It should be the rule, however, that all biting mosquitoes be regarded as disease carriers until proven otherwise, either by previously established information or by a thorough survey of the area, or by both. Since control measures are best planned when the enemy is identified, it is vital that the different types of mosquitoes be recognized and particularly that the most dangerous disease vectors be quickly identified so that control measures will not be wasted on those that cannot transmit disease.

(b) The most important genera which include vectors of disease are: Anopheles, Aedes, Culex, and Mansonia. Mosquitoes in the genus Anopheles, several species of which are efficient transmitters of malaria, are known as "anophelines." They are easy to distinguish from all the other genera, called culicines," in both adult and larval stages.

8. Importance of Identification. - As stated above, only certain species of mosquitoes transmit disease and these are carriers of specific diseases. It is important, therefore, to be able to differentiate the genera, and in some instances the species. In general, the basic problem is that of distinguishing between anophelines and culicines.

9. Differentiation of Sexes. - The sexes of adults in all genera can be readily differentiated by the antennae, which for the males are plumose while the antennae of the females have only short hairs. A peculiar feature of the anopheline female is the almost equal length of palpi and proboscis.

10. Identification of Larvae. - Larvae of the Anopheles, Aedes, and Culex genera can be differentiated in the field by the resting position they assume in the water, and by the presence or absence, or differences in shape, of the breathing tube. The anopheline larva, when at rest, usually floats in a horizontal position immediately beneath the surface film, and possesses a stigmatic opening instead of a breathing tube on the eighth abdominal segment. The culicine larva, in contrast, is suspended head downward by means of a breathing tube at an angle of approximately 45 degrees with the surface of the

water. Species of the genus Aedes possess a relatively short, conical breathing tube while those of the genus Culex have an elongated and relatively slender tube.

11. Identification of Pupae.--Differentiation of genera by simple field inspection of the pupae is difficult but may be accomplished by examination of the breathing trumpets or tubes. The breathing tubes of the Anopheles pupae are short, broad, and funnel shaped. They arise from about the middle of the cephalo-thorax and are split in front. The breathing tubes of the Aedes pupae are short and broad, but the opening is triangular in shape and there is no split. Culex pupae possess long and slender breathing tubes which show no split and which are attached to the posterior of the cephalo-thorax.

12. Identification of Adults. The genera of adult mosquitoes can be distinguished by difference in structure, markings and posture. In the genus Anopheles, the palpi of both sexes are nearly or quite as long as the proboscis and the wings are frequently spotted. When at rest, with few exceptions, they assume a posture in which the body projects at an acute angle from the resting surface. In other genera, the palpi of the females are much shorter than the proboscis, the wings are usually without spots, and the resting position of the body is more nearly parallel to the resting surface. In the genus Aedes, the adults in general are small black or dark brown individuals having a number of white or silvery markings. This genus may be distinguished from a related genus Culex by the tapered end of the abdomen and the projecting cerci; by the presence of postspiracular bristles, and the absence of spiracular bristles. Aedes aegypti is the most important representative because of its wide distribution and ability to transmit dengue and yellow fever. It is distinguished by two median straight and two lateral curved silvery white lines on the dorsum of the thorax which form a lyre-shaped design. In the genera Culex and Aedes, the adult has a trilobed scutellum, the abdomen is blunt and clothed with scales and the postspiracular bristles are absent. In general the adults of this genus are more or less brown in color and pale bands may occur on the dorsal surface of the abdomen (Figure 10-1.)

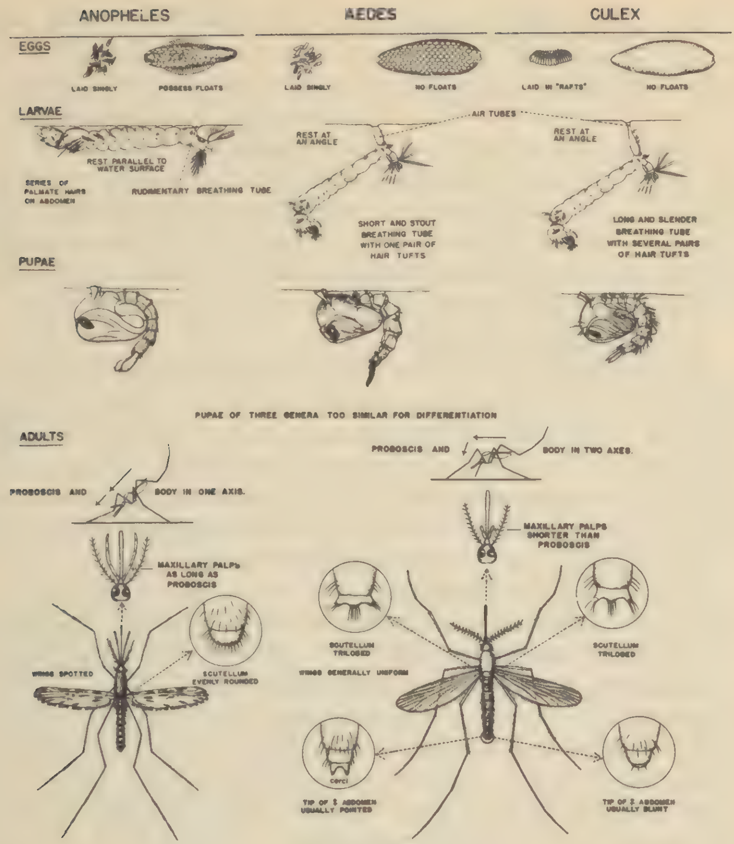


Figure 10-1.--Principal characters for identifying the three genera of medical importance

Section II.--MOSQUITO DISTRIBUTION

13. The Importance of Intelligence. - It is essential to have information about the enemy to conduct a successful campaign. The 1,700 species of mosquitoes vary widely in biting and breeding habits and in their ability to transmit disease. Different methods of attack, are required, depending on the habits of the disease-bearing mosquitoes in any area. For example, an extensive larvicidal and drainage program in swamps would be of little value in controlling an outbreak of dengue fever since the principal vectors of dengue, Aedes aegypti and Aedes albopictus breed in artificial water containers, in tree holes and in the case of albopictus in leaf bracts of arboreal plants.

14. Previously Determined Information. - The fullest possible use should be made of the available information in studies and reports on the mosquitoes present in an area previously surveyed. The experience of malaria control and epidemiology units, or other scientific groups previously in an area, is particularly helpful in gaining information concerning the habits of the local mosquitoes and the diseases transmitted by them. Such information should not, however, be considered as infallible and all supplementary information available should be compiled by the individual involved in actual control.

15. Mosquito Surveys.

(a) Mosquito surveys made in the field must be relied on for much of the information necessary into the proper planning of control programs. Planning and control can be carried on concurrently, however, and obvious control measures should not be postponed pending completion of observations. The following steps, all of which may be undertaken simultaneously, are recommended in a newly occupied area.

(b) Locate the Breeding Places of Important Species.

(1) A systematic survey to determine the location of breeding places should be condueted before extensive antilarval measures are undertaken and must be conducted during the course of the program to locate new breeding places that may develop. It should be borne in mind that some species of mosquitoes are restricted in their choice of breeding places while others are adaptable to a wide variety of breeding conditions. The type of breeding place of each important species in a given area, including information on the type of water collection or containers, degree of sunshine or shade, presence of aquatic vegetation, and whether the water is running or standing, fresh or brackish, should be determined. As the survey progresses, breeding places should be assigned station numbers to facilitate record keeping. A record of each larval collection giving complete information should be kept.

(2) Potential breeding places include almost every kind of water collection or damp place. Examples of typical breeding places are ponds, lakes, streams, springs, seepage areas, swamps, fresh and saltwater marshes, lagoons, rain puddles, road ruts, irrigation and roadside ditches, rice fields, wells, water troughs, rain barrels, eaves troughs, septic tanks, excavations, tree and stump holes, axils of trees such as pandanus and sago palms, water holding plants such as the epiphytic bromeliads, and other tropical plants, hoof prints, road ruts, broken coco-

nut shells and husks, cracks in hydraulic fills, and numerous aritifical containers such as sagging tent covers and tarpaulins, buckets, cans, barrels, discarded tires, and empty beer bottles.

(3) Special care is required to detect the presence of larvae. Larvae often seek the cover of aquatic vegetation or descend beneath the surface of water when disturbed Equipment necessary to collect larvae consists of a water dipper, preferably white enamel, a medicine dropper, and a series of vials or small bottles. The dipper should be used with as little agitation of the water as possible. It should be thrust quickly into the water at such an angle that the water flows in over one side of the lip. If vegetation or debris is present, the dipper should be thrust into a clear space and the scoop made toward the edge of the floating material with a continuous motion. If the water obtained is not clear, careful examination should be made before discarding the sample, and sufficient time allowed for those at the bottom of the dipper to swim to the surface. Larvae should be transferred to vials by means of the dropper and the vials should be marked with the number assigned to the breeding place. Since agitation during transport to the laboratory often breaks the fine larval structures necessary for identification, only enough water should be left in the vial to moisten the interior. The larvae will then stick to the sides of the container.

(4) If the larvae are to be retained for rearing adults, a sample of the water in which they were found should be put in a separate bottle, and the larvae transferred to this water in the laboratory. A piece of gauze should be fastened over the mouth of the bottle. Larvae should be fed small quantities of bread crumbs, or in the case of anophelines, a little baker's yeast floating on a small piece of paper toweling or filter paper. To remove adults which emerge in the bottle, a small piece of cotton soaked with chloroform, or the open end of a killing bottle (Par. 15(c), should be placed on top of the gauze until they are stunned, then they should be taken out with a pair of forceps. Adults should be allowed to harden for several hours after merging before being killed.

(c) Determine Prevalence of Mosquitoes and Effectiveness of Control by Periodic Inspections for Larvae and Establishment of Adult Collection Stations.

(1) Periodic inspections of known breeding places must be made, preferably at not less than weekly intervals, in order to check on the effectiveness of control measures.

Records of these inspections similar to those for the initial survey should be kept.

(2) The index to the effectiveness of control work is the prevalence of adult mosquitoes. A record system for obtaining comparative results from night to night or day to day is necessary. Collections should be made during the night or day at the time when the mosquitoes are known to be actively biting. Mosquitoes are most active just before the first gray of dawn. Anophelines and other nocturnal species will be observed in areas where there are human beings or animals; daytime biters can be collected in similar locations during the day. Adult mosquitoes of many night-biting species, particularly anophelines, can be caught, if necessary, in their daytime hiding places, such as tree holes, culverts, undersides of bridges, and inside and under houses, native huts, stables, and latrines. A flashlight or other type of light will prove invaluable in collecting mosquitoes in these locations. If enough natural resting places cannot be found, boxes or barrels should be stationed at convenient places to test the prevalence of mosquitoes. To be successful kegs, barrels and boxes must be placed so that morning sun will not shine in them.

(3)Killing bottles and suction tubes are useful devices for collecting adult mosquitoes. To prepare a killing bottle, a large test tube or vial should be obtained. Cut rubber bands or scrap-rubber should be placed in the bottom of the container to the depth of about 1/2 inch, saturated with chloroform, covered with a layer of cotton or similar material, and secured in place with a disc of cardboard or stiff paper. To prevent loss of the chloroform the container must be kept securely sealed (Figure 10-2(a)). A simple suction tube consisting of a piece of glass tube constructed at one end to hold a section of rubber tubing and snugly fitted with a short shim metal tube to which is soldered a piece of wire gauze is a useful instrument for collecting adults (Figure 10-2(b)). A suction tube with which specimens are not so likely to become mutilated may be constructed of a large test tube vial inserted in the suction line (as shown in Figure 10-2(C)) and with a piece of gauze over the air outlet.

(4) Light traps or animal bait traps are an efficient means of catching adult mosquito specimens, but should not be wholly relied upon for an accurate measure of the relative abundance of different species since the attraction of certain types of animals and individuals vary among

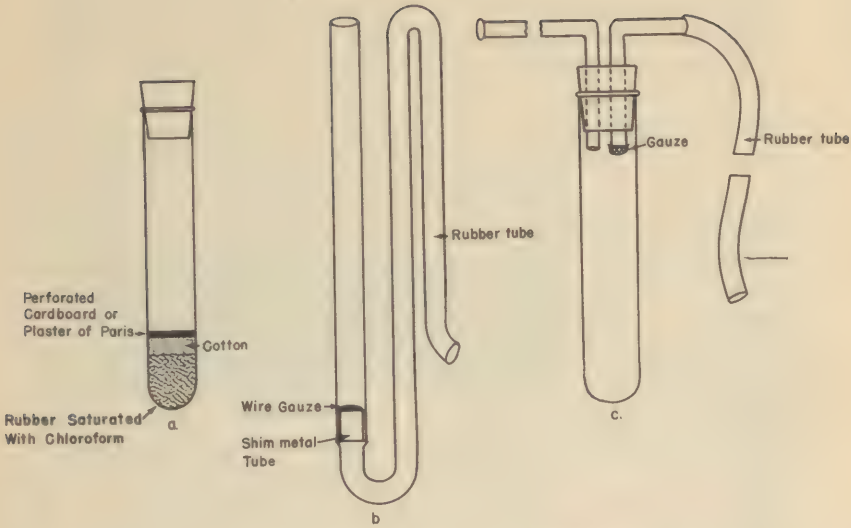


Figure 10-2.--Collecting devices for adult mosquitoes

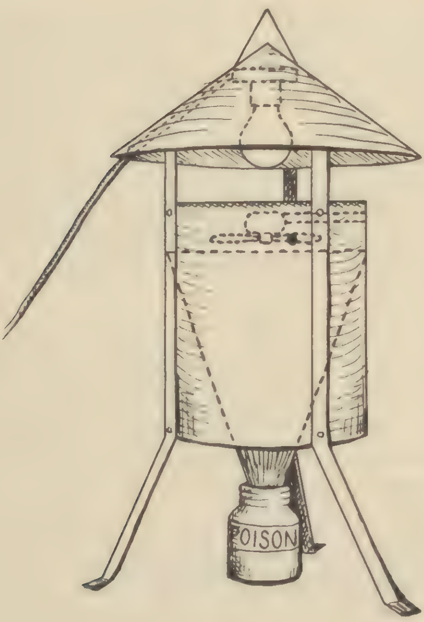


Figure 10-3.--New Jersey type light trap. Detail of construction

species of mosquitoes. Also, the effectiveness of animal or light traps varies from day to day with temperature, wind, and other weather conditions. The New Jersey type light trap, consisting of an electric light source, to which the mosquitoes are attracted, and a small electric fan to draw the insects into a killing jar containing sodium or potassium cyanide, (Figure 10-3) is the preferred type of light trap. An animal bait trap consists of a screened shelter having an aperture to permit entrance of the mosquitoes, with a large animal, such as a horse, enclosed therein. (Figure 10-4). Other types of animals may be utilized, or several types may be used at different times in order that various species of mosquitoes may be collected. A record of adult collection thus made should be kept in a manner similar to that for larval collections. The following is an example of a useful record card:

ADULT COLLECTIONS

Collection No: ____________________ Date ______________

Station No: ____________________

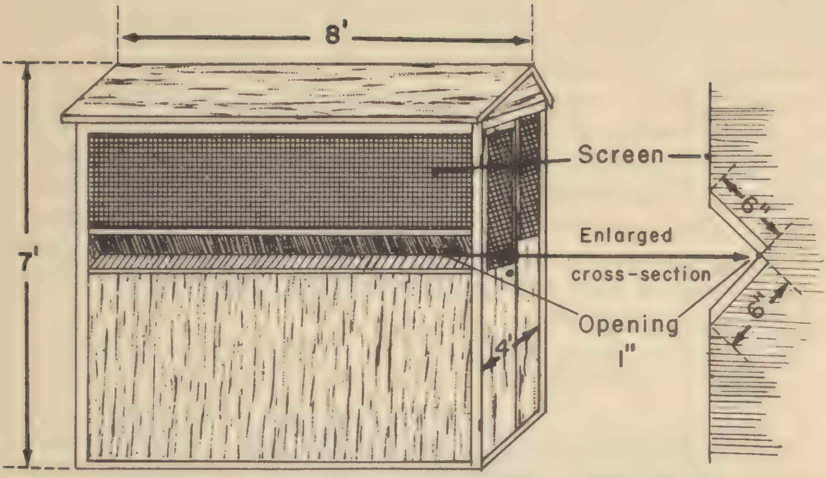
Location: ____________________

Weather Conditions: ______________

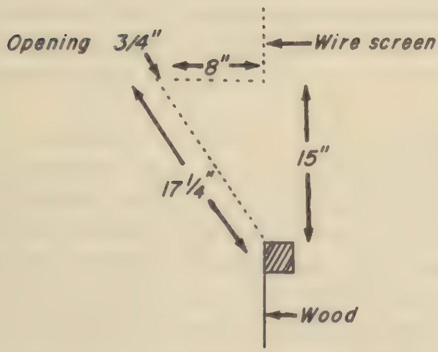
Species Females Males

(d) Determine the Species of Mosquitoes Present and Their Abundance in the Area. - In addition to control measures taken against mosquitoes which are known to transmit diseases in the area, vigilance should be maintained to detect previously suspected or new vectors. When mosquitoes cannot be identified in the field, specimens should be sent to the U. S. Naval Medical Center, Bethesda, Maryland, for the necessary study. Detailed information on preserving, packing, and shipping insects for identification is given in BuMed c/l 43-124 or latest modification thereof.

(e) Prepare a Map of the Area. - A map showing breeding places in relation to camp sites and native populations is of inestimable value in planning and conducting a control program. Aerial maps or contour maps, supplemented by aerial and ground reconnaissance, are particularly useful before starting a survey. Tracings may be made from aerial maps, with detail obtained from ground reconnaissance sketched in. Contour maps showing elevations are especially helpful for drainage work. A record of draining, filling, ditching, clearing, etc., can be made on the map as the work progresses. If maps or aerial photos are not available, free-hand sketches may be made with the locations of features of the terrain estimated until more comprehensive surveys and maps can be made.



A. CARIBBEAN TRAP



B. MODIFICATION OF INGRESS BAFFLE (EGYPTIAN TRAP)

Figure 10-4.--Animal bait trap

Section III.--CONTROL METHODS

16. Choice of Control Methods. - Operations for mosquito control depend on the disease encountered, the species of mosquitoes present, and the location and nature of the military operation. Military considerations during the earlier phases of occupation often necessitate emphasis on temporary control measures. As the situation improves, more permanent procedures should be put into effect. Control measures in the beginning must necessarily be directed against all mosquitoes without special attention to species control unless the personnel assigned to mosquito control are thoroughly familiar with the disease vectors present, their relative abundance, types of breeding places, and habits. As more information is gained through study or by personal observation, specialized control should be emphasized.

Section IV.--INDIVIDUAL PROTECTION

17. Necessity for Individual Protection. - Measures conducted by the individual for his own protection against mosquito-borne diseases are invaluable supplementary measures to organized mosquito control programs. They are essential in highly endemic areas during the earlier phases of occupation, especially in localities where protection of the entire area cannot be undertaken. Explosive epidemics of dengue fever and malaria may cripple a military force during the earlier phases of an operation, if individual protective measures are not rigidly enforced by the commanding officer. Filariasis alone (often referred to as "mumu" or elephantiasis,) if present, justifies the continuous use of personal protective measures.

18. Repellents.

(a) Insect repellent (Catalog of Navy Material, Stock No. 51-D-237-400, Dimethyl Phthalate, in 2 oz bottles) should be used in all areas where mosquito-borne diseases are prevalent. When the repellent is properly applied the repellency usually persists for about 3 to 4 hours, but the duration is shortened by such factors as rain and perspiration, and its efficiency varies for different species of mosquitoes. To use the repellent properly, shake a few drops into the palm of the hand, and after rubbing the hands together, make an even application on all exposed skin surfaces. Begin with the back of the neck, ears and back of the head, then the face (avoiding eyes and lips). Repellent should be used sparingly on the forehead. Hands and wrists should receive heavier application.

Heaviest repellent application should be made to the ankles. This is the most important area to be treated with repellent and it should be accomplished in the following manner. Shake a few drops of repellent in the palm of one hand, rub hands together, push down sock and wipe repellent off hands onto ankle. Excess repellent should then be wiped off hands on sock after it is pulled up. Repeat for other ankle and sock. Trouser legs should then be pulled down. This procedure is unnecessary if leggings or combat boots are worn. Care should be taken to avoid mucous membranes, since the material causes a transitory, disagreeable, burning sensation. The repellent should also be applied to clothing at points where insects may bite through, such as to the clothing over the shoulder blades, ankles, knees, etc. Repellent for the impregnation of clothing (Catalog of Navy Material, Stock No. 51-D-237-425,) dimethyl phthalate, supplied in one gallon containers is of particular value in preventing mosquito bites through garments for a period of a few days at least. The dimethyl phthalate may be applied undiluted to clothing with a 'flit gun' or other large droplet type of sprayer. Clothing may be sprayed while being worn if the wearer covers his eyes to protect them from the spray. Clothing may be treated off the body by first turning the garments inside out, buttoning, and spraying inside the reversed garment holding the sleeves, neck of shirt, and bottoms of trousers closed. Two ounces are sufficient to treat one uniform completely. Untreated underwear shorts should be worn under such treated uniforms to prevent skin irritation. Laxity of many individuals. regarding the use of repellents requires enforced or supervised use, particularly during patrols, sentry duty, and other periods of unavoidable exposure.

(b) Insect repellent in 2-ounce bottles should be obtained by all naval and Marine Corps activities on requisition to the nearest naval supply depot or storehouse in such quantities to provide an allowance of three two-ounce bottles per man per month. This allowance is established for malarious areas; but in areas not deemed malarious, the repellent should be available for protection against pest insects.

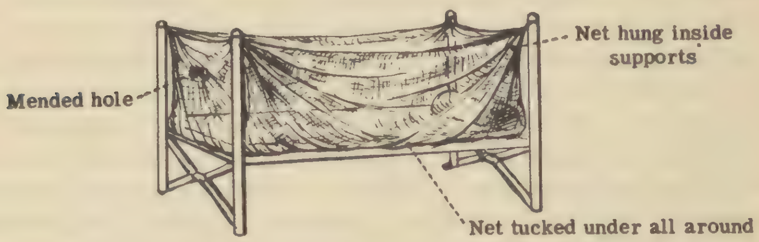
19. Protective Clothing - Mosquitoes do not bite readily through clothing; the heavier the clothing the greater the protection afforded. Long sleeves and trousers, therefore, should be the required uniform from an hour before sundown to an hour after sunup in malarious areas. In addition, if head nets, gloves, and leggings are available and practicable they should be utilized, but if it is not practicable to use them, a large measure of protection will be afforded by ordinary

clothing. Lifting head nets or cutting holes in them in order to smoke nullifies much of their value. It should be pointed out to personnel that cigarettes and pipes can be held directly through the net without mutilating it. Treating the headnet with DDT will greatly increase its protective value, as large numbers of mosquitoes will be killed by it.

20. Bed Nets.

(a) Bed nets must be used by all personnel in areas infested with disease-carrying mosquitoes. Even in screened barracks where a number of men are quartered in one room, bed nets are sometimes necessary equipment because mosquitoes may gain entrance through opened doors or poorly fitted screens.

(b) Instruction and discipline regarding the proper use of bed nets are essential (Figure 10-5.) The lower edge of the net must be carefully tucked under the mattress or bedding so that no openings remain for mosquitoes to enter. The net must be stretched tightly to prevent parts of the body coming in contact with it. If the bedding is placed on the ground, the



A - THE RIGHT WAY TO HANG YOUR BED NET!

B - THE WRONG WAY TO HANG YOUR BED NET!

Figure 10-5.--How to hang a bed net

bottom edges of the net should be secured with a generous supply of sand or loose dirt. DDT sprayed on the net (20 oz. of 5 per cent solution per net) will leave such a residue of DDT on the meshes that all mosquitoes touching it will lose interest in biting in a few minutes, and die shortly after. When entering, open the net for the briefest time possible and raise it no higher than necessary. Periodic inspections should be made of the nets and any holes discovered must be promptly repaired. DDT should be reapplied to the nets every two or three months. Learning to sleep under a net requires some practice. Men should be warned against sleeping with knees, buttocks, or elbows against the net.

21. Aerosol Insecticides.

(a) A highly efficient insecticide for killing adult mosquitoes in tents, huts, shelters, and buildings is provided in the aerosol bomb. This bomb consists of a steel container in which the insecticide is dissolved in Freon 12 as the carrier, propellent. The bomb contains a small orifice through which the insecticide mixture is released when the valve is opened. The Freon, through liquid under pressure evaporates when released leaving what is termed an "aerosol," comprised of minute particles of insecticide, suspended in the air.

(b) The aerosol insecticide is highly concentrated, and a much smaller quantity of material is needed to spray a room than with the old type flit-gun. One pound of aerosol insecticide is enough for about 12 minutes' total spraying time and is sufficient for spraying 150,000 cubic feet of space. About 5 or 6 seconds spraying is required for 1,000 cubic feet, if the room is not ventilated.

A full bomb delivers faster than one nearly empty, so more time should be allowed when the bomb is less than one-third full.

(c) The aerosol insecticide is available in 1, 2 or 5 pound refillable dispensers. Cylinders of 40-pound capacity are also available for refilling the dispensers.

22. Contact with Native Carriers.

(a) Commanding officers must be alert to prevent close association of naval personnel with natives, particularly in and around native habitations. In malarious areas, native environs should be restricted from an hour before sundown to an hour after sunup due to the fact that anopheline mosquitoes are mainly night biters. On the other hand many of the culicine vectors of dengue fever and filariasis are day and night biters; and native settlements in which these diseases are prevalent must be avoided at all hours of the day or night.

(b) Generous use of repellents and, if practicable, a residual spray application of DDT to the inside of native dwellings and other buildings in areas where it is necessary to associate with native carriers are wise precautions.

(c) Outdoor activities such as open air movies, night baseball, or swimming, are to be discouraged after sundown, until area control is perfected.

23. Suppressive Treatment for Malaria. - Consult medical officer in command.

Section V.--AREA CONTROL OR GROUP PROTECTION

24. Personnel Requirements. - Area control for the protection of groups of men, in contrast to mosquito control measures conducted by the individual for his personal protection, is usually conducted by personnel specially trained for the task. Intensive antimosquito work directed against all vulnerable stages of mosquitoes, varying from emergency measures of a strictly temporary nature to long-term control projects with permanent installations, may be needed.

25. Methods. - The two primary methods of approach are (a) against adult mosquitoes and (b) against the immature stages, mainly larvae and pupae.

Section VI.--MEASURES AGAINST ADULT MOSQUITOES (AREA CONTROL)

26. Effectiveness of Control of Adult Mosquitoes. Control measures directed against adult mosquitoes are effective in reducing mosquitoe-borne disease rates, particularly in the early phases of occupation when immediate results are required.

27. Aerosol Insecticide.

(a) Periodic spraying with aerosol insecticide of barracks, galleys, mess halls, theaters, clubs, and other buildings where groups of men congregate is highly effective in reducing transmission of mosquito-borne diseases. Trained personnel responsible for routine treatment of buildings once a day increase efficiency and eliminate dependence on individual initiative. When these buildings are screened, periodic application of DDT to screens and bulkheads is preferable.

28. Spraying from Aircraft.

(a) The use of aircraft to spray DDT solutions is an effective and rapid method of spray-killing adult mosquitoes over large areas. The method is particularly useful during the early phases of occupation before organized spray-killing of adult mosquitoes and larvicidal operations on the ground can be initiated. Such efforts may also be used as a routine

procedure to supplement the work of ground crews. The use of aircraft for this purpose is made possible by employing high concentrations of DDT, permitting coverage of a large acreage with one planeload of spray.

(b) A solution of 5 to 10 percent DDT in Diesel fuel oil (using about 10 percent or more of an auxiliary solvent such as xylene cyclohexanone, or alkylated naphthylines if necessary) generally gives good control of mosquitoes when applied at the rate of about 1 to 2 quarts per acre. Larger quantities may be required under some conditions, particularly where control of adult insects is the primary objective. Land or carrier based planes are useful for spraying areas during the early phases of occupation before other control measures can be put into effect. By the use of a belly tank or two-wing tanks, such planes will carry 300 or more gallons of spray. Slower observation planes are more suitable for accurate spot spraying, and better for difficult terrain. For larger areas, planes having a capacity of several hundred gallons are more suitable. Attack type aircraft with droppable wing tanks is usually assigned for this purpose, in established bases.

(c) Distribution of DDT aerosols (insecticidal smokes) from airplanes is also a promising method for rapid elimination of adult mosquitoes from large areas.

(d) Spraying apparatus has been developed that can be quickly installed in observation or in naval combat planes. New and more efficient equipment is in a state of rapid development. Descriptions of apparatus, procedures and means of procuring equipment may be obtained from the Bureau of Medicine and Surgery.

29. Screening.- The spray-killing of adult mosquitoes is only temporarily effective in the absence of screened enclosures. Windows, doors, and ventilating spaces of all buildings, such as hospitals, mess halls, and barracks, should be screened enclosures. Screening should be done as soon as feasible and the screening maintained in good repair. Inasmuch as a few mosquitoes of certain species, such as Aedes aegypti, will penetrate on ordinary 16-mesh screen, it is preferable to use an 18-mesh screen, if available. Bronze or copper screening is more lasting than galvanized or iron screening but the usefulness of the latter can be prolonged with a thin coat of paint. Plastic screen (Saran) has the advantage of being noncorrosive and is, therefore, more durable than metal under normal conditions. It is somewhat more easily torn, however, and is destroyed by flame. All screens should be painted with 5%

solutions of DDT every month or two during the fly and mosquito season.

30. Construction for Mosquito Protection.

(a) Comfortable quarters with adequate ventilation will reduce mosquito bites by encouraging personnel to remain indoors when not actively employed. Temporary buildings should be constructed so that no cracks remain between the boards of walls or floors. Intervals likely to be left at the juncture of walls and roof, openings such as chimneys and

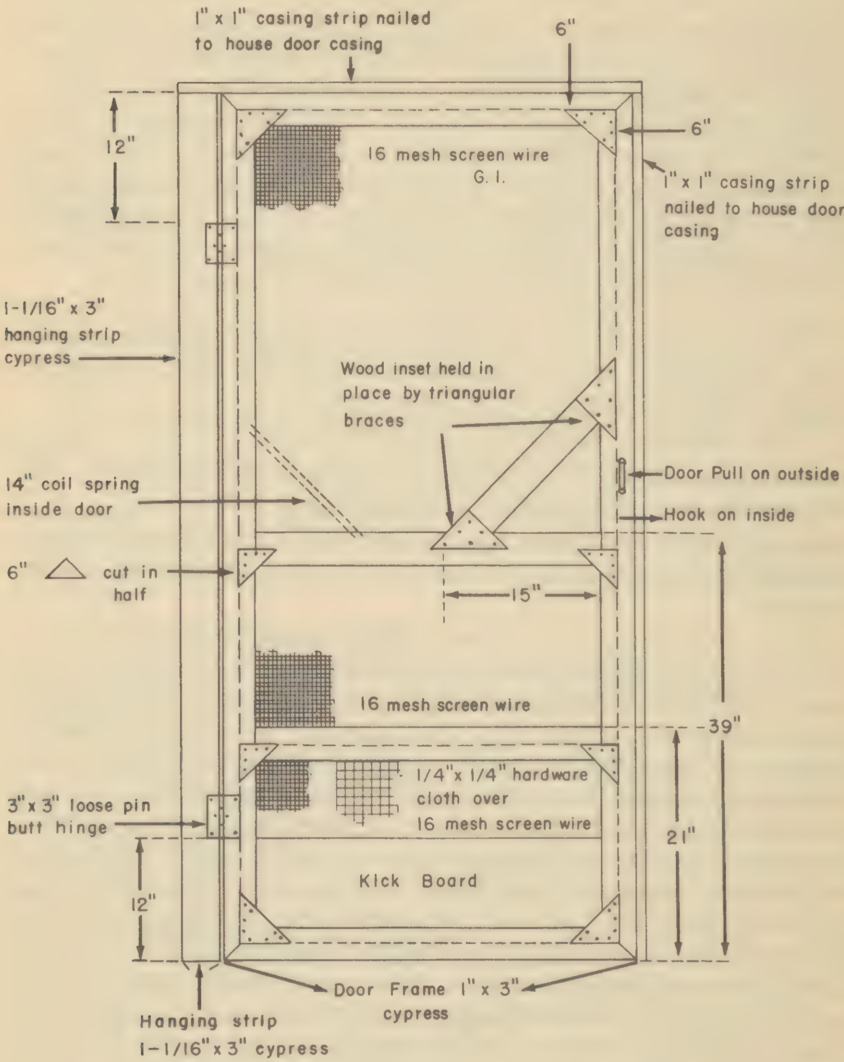


Figure 10-9.--Details of screen door

vents, cracks between doors and casings, and the proper placement of batten strips require particular attention. If necessary, cracks and knotholes can be calked with oakum or cotton. The edges of window screens will remain mosquito-proof if permanetly secured and if provision is made for opening and closing shutters or windows from the inside.

(b) Screen doors should open outward and should be located on the windward side of buildings, since insects tend to collect on the leeward side. Also, the wind helps keep doors on the windward side closed. A vestibule with two screen doors provides additional protection. Otherwise, doors are best kept to a minimum. Usefulness of screen doors is prolonged by kickboards and wooden cross strips where hands and feet are likely to cause injury to the screen. (Figure 10-9.) All screen doors should be fitted with automatic quick-acting closing devices.

(c) A special detail to make periodic inspections of buildings for broken screens or openings and for repairing such openings should be activated.

31. Residual Sprays. - A supplementary treatment of confined spaces that is effective over a prolonged period consists of spraying oil solutions or emulsions of DDT on screens, in interiors, beneath eaves, and in other mosquito resting places. Because the insect is killed by contact with the dry deposit of DDT left of the surface as a residue after the spray has evaporated, the treatment is referred to as a residual spray. Mosquitoes are intoxicated after a few minutes, and killed within 24 hours after alighting on surfaces sprayed with DDT. The treatment of the interior of native huts is especially valuable, as it affords protection by killing many mosquitoes before they have an opportunity to transmit disease to others in the same building or area. Residual sprays can also be used to reduce the number of adult mosquitoes out of doors, as in bivouac areas. The use of DDT residual sprays on vegetation for obtaining prolonged protection in the area is seldom indicated. For preparation and use of DDT residual sprays, refer to Chapter 9.

32. Isolation from Carriers and Vectors. - The chain of mosquito-borne diseases is broken by the absence of either human carriers or the mosquito vectors or both. Selection of sites for permanent bases without regard to proximity of infected natives and mosquito breeding places results in large numbers of personnel being incapacitated and often necessitates extensive mosquito control work. Whenever time and military considerations permit, permanent bases must be

established only after thorough mosquito surveys and, if practicable, should be located beyond the effective mosquito flight range from important breeding places. Locations adjacent to native villages must be avoided. Removal of natives and native habitations from the area, however, is equally effective and is sometimes more easily accomplished.

Section VII.--MEASURES AGAINST IMMATURE STAGES OF MOSQUITOES (AREA CONTROL)

33. Vulnerability of Immature Stages. - The immature stages of the mosquito comprise the most vulnerable link in its life cycle and are subject to a variety of control measures. The suitability of the type of control depends on the nature of the breeding place, terrain, time available, work involved, and other factors.

34. Larvicides

(a) Larvicides are often relied upon not only during the early phases of a mosquito control program before drainage and other permanent measures can be initiated, but also for periodic treatment of persistent breeding places not possible or practicable to eliminate.

(b) DDT Larvicides. - The most efficient larvicide is DDT in oil solution in emulsion or in a dust. Much smaller quantities of oil containing DDT are required than when oil alone is used. One quart of Diesel fuel oil containing 5 percent DDT (about 21/4 pounds in 5 gallons of oil) or 5 quarts of oil containing 1 percent DDT are sufficient to treat an acre of water surface. This rate provides 0.1 pound of DDT to the acre. The same amount of DDT per acre is required when the emulsion or dust is used. For descriptions of equipment, preparation, and application of DDT Larvicides refer to Chapter 9.

(c) Aircraft Spraying of DDT Larvicides. - Refer to Chapter 9

(d) Oil Sprays.

(1) Diesel oil, Grade F.S.No. 2 fuel oil, or crankcase oil thinned with kerosene, without DDT may be used for larviciding where DDT is not available, although larger quantities of oil are required. Usually 20 to 30 gallons of oil per acre or more are needed to form a thin continuous film. More oil is required to obtain a film of oil on water having vegetation and organic debris on the surface than on clear water.

(2) The oil is usually applied with either the 3-gallon cylinder type insect sprayer, Catalog of Navy Material

Stock No. 41-S-4125, or for small jobs, the 3 quart continuous spray insect sprayer Catalog of Navy Material Stock No. 41-S-4120 is light and very effective. All equipment used for spraying must have oil-resistant hose and gaskets. Fifty gallon power sprayers (Stock No. 40-S-2590-18) have been procured for mounting on trucks and can be used in boats to spray an oil-water mixture along margins of lakes or large lagoons.

(3) Several methods have been devised for continuous application of small quantities of oil to control larval breeding along the edges of slow-moving streams or canals. A simple drip-can may be prepared by placing a 5-gallon can three or four feet above the water with a small nail hole through the bottom, and a packing of waste or string wrapped under the head to retard the flow and prevent clogging by small particles (a petcock may be used). About 20 to 70 drops per minute are required for a small, slow moving stream. Drip cans have been reported to be unsatisfactory for dispersing oil containing DDT as there is likely to be crystallization at the opening causing plugging. A submerged oiler satisfactory for DDT solutions as well as for oil alone can be made from a can of oil beneath the surface with two holes in the top of sufficient size to permit gradual replacement of the oil by water. The container is anchored beneath the surface with the holes at different levels so that replacement of the oil by water will take place. An oil sock made by filling a bag with oil-saturated rags, sawdust, or waste, will release oil slowly when anchored in a stream. These methods, widely recommended are seldom satisfactory in running water.

(e) Paris Green - Paris green (copper aceto-arsenite) used as a dust is an effective stomach poison against anopheline larvae. It is mixed with a diluent such as hydrated lime or talc to contain 5 to 10 percent Paris green for ground dusting or as high as 50 percent for airplane dusting and applied at the rate of about 1/2 to 1 pound of Paris green per acre. The material floats on the surface of the water and acts as a stomach poison when ingested by the surface-feeding anopheline larvae. The dust is not very effective against subsurface feeding culicine larvae unless applied in large quantities. Paris green does not kill pupae since pupae do not feed. It is rarely used since DDT has become available.

35. Filling. - One of the most thorough methods of mosquito control is to eliminate breeding places by filling them with earth. Such places may range from small depressions

filled by hand shoveling, to large ponds or swampy areas which may be filled by means of dump trucks, bulldozers, draglines, or hydraulic dredges. Large scale filling is adaptable to locations situated near sites where excavating or dredging is being done. Care must be taken to begin the fill at the point farthest away from the outlet in order to prevent formation of a barrier to drainage. Failure to do this is a common error particularly in hydraulic fills.

36. Drainage.

(a) Applicability - Removal of water by drainage is the most widely applicable method of eliminating mosquito breeding areas. Water accumulations to which a variety of drainage methods are applicable, depending on the type of water collection and the nature of the terrain, consist of lakes, ponds, rain puddles, and storm water collections; seepage or spring water emerging from the soil at low levels to form swampy areas or streams; and tide water on beaches, in landlocked pools, and in lagoons or marshes which remain after the recession of unusually high tides.

(b) Open Ditches. - Open ditches usually provide the most rapid and economical drainage system. Several types of open ditches may be classified according to their function.

(1) Main drainage ditches are for surface water run-off. The drainage system usually comprises a primary ditch, fed by one or more subsidiary or lateral ditches, conducting the water to a conventient natural outfall such as a river, lake or bay.

(2) Diversion ditches are constructed to divert water from its natural course for the purpose of conducting water (a) away from a swampy area to a natural outfall, (b) from a crooked stream consisting of numerous breeding places to a straight ditch, or (c) from dangerous breeding places to a localized area where larvae can be more easily controlled.

(3) Seepage, interceptor, or contour ditches.- Water sometimes percolates through soil from high ground and emerges in low places to form a swampy or seepage area. A ditch located on the high side of, or surrounding a seepage area will intercept the seepage water and conduct it to a primary ditch or other outfall (Figure 10-10).

(4) Displacement drainage ditches are for removal of water from swampy areas only slightly above the level of the water in the outfall, not permitting sufficient grade for gravity flow. Displacement ditches may be flushed by tidal action or may concentrate the water for removal by pumping or to facilitate other means of control.

(5) Pilot drains are small drains sometimes useful to remove excessive water along the proposed ditch site during construction.

(c) Survey of the Open Ditch. - The proper location, size, shape and grade of a ditch depend on the interrelations of natural terrain, soil conditions and water capacity required. A thorough survey before beginning work may save time and labor. The following steps may be used as a guide:

(1) Find the natural or most suitable outfall by reconnaissance of the entire drainage area.

(2) Plot tentatively the general course of the main ditch by inspection, taking advantage of natural features of the terrain, then plot the minimum number of lateral ditches apparently required. Start from the lowest point, or outfall, and work up stream.

(3) Make a profile survey. First determine the comparative levels along the course of the ditch, preferably with the aid of an engineer's level. If an instrument is not available or if less accuracy is required, other methods may be used. One of the simplest consists of driving stakes along the proposed ditch at 25 foot intervals

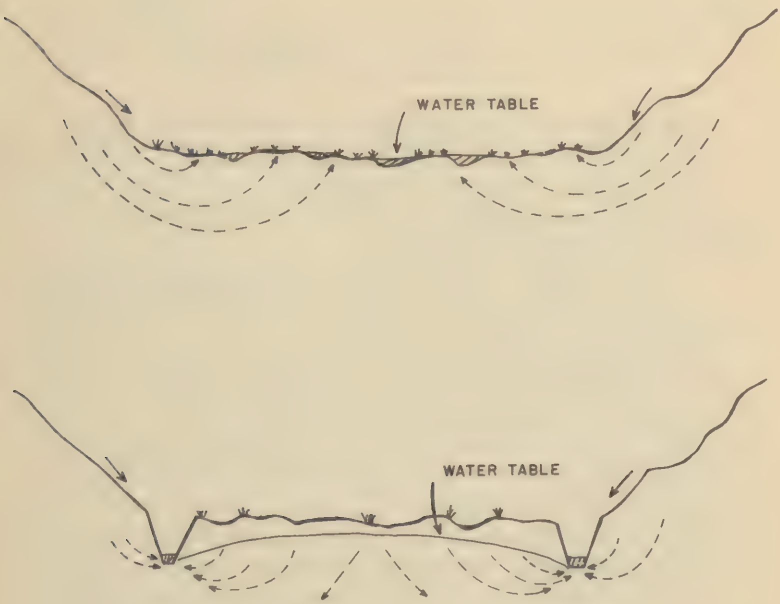


Figure 10-10.--Effect of interceptor ditches on drainage of seepage area

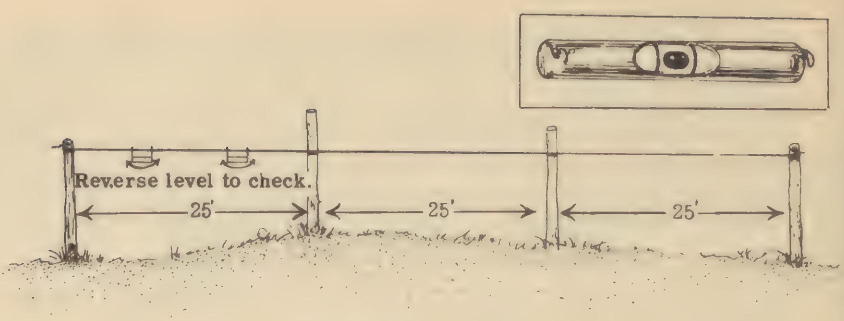


Figure 10-11.--Setting up chalk line for profile survey

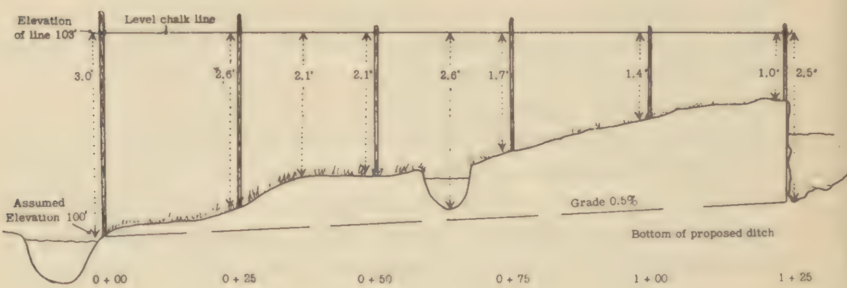


Figure 10-12.--Diagram of profile survey by means of chalk line, vertical proportion exaggerated to emphasize differences in elevation

and stretching a chalk line from stake to stake with the aid of a line level (Figure 10-11). Comparative ground elevations at regular intervals can be determined by measuring the distance from the level chalk line to the ground (Figure 10-12).

(4) Draw a profile map from the profile data and plot the grade (vertical drop) of the bottom of the ditch. The dut (depth of ditch) at any point may be calculated from the ground elevations (Figure 10-11, 10-12, 10-13).

(5) Prepare a cut sheet (a table showing the depth of the bottom of the ditch below the ground elevation at required intervals) for use in the following step.

(6) Set up batter boards or T boards at convenient intervals as guides for making the predetermined cut. A batter board consists of a board nailed across stakes on opposite sides of the proposed ditch from which a measure can be made to assure that the bottom of the ditch will be the same distance from the top of each board. A chalk line may be drawn between the batter boards. T

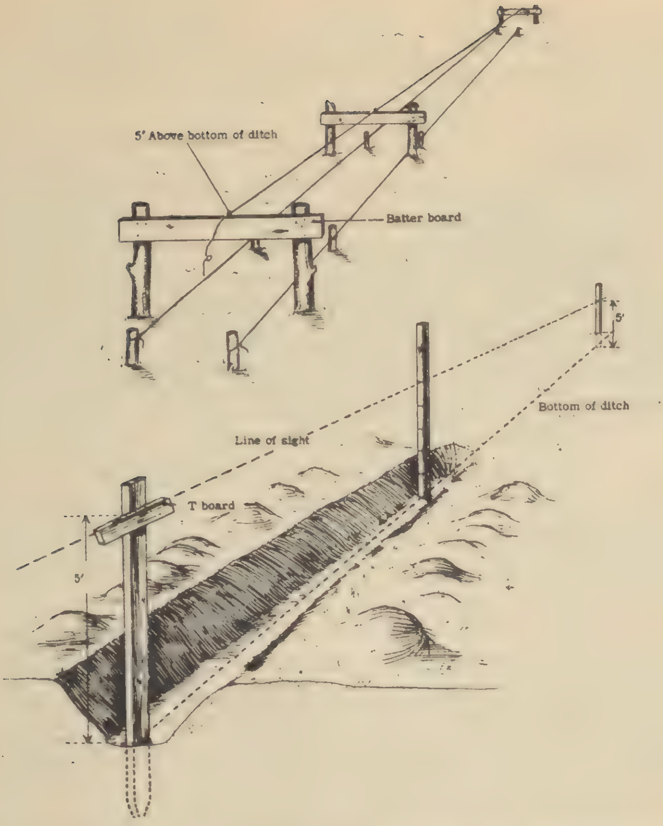


Figure 10-13.--Use of batter and T-boards to determine the grade line of a ditch

boards, consisting of short cross boards nailed to stake markers along the center line of the proposed ditch, serve the same purpose (Figure 10-13).

(d) Features of the Open Ditch. - The following points are desired features of an open ditch under average conditions.

(1) Location of ditch.- Locate the ditch system to drain off the water with as few linear feet of ditch as possible while taking advantage of the natural terrain.

(2) Direction of ditch.- Where terrain permits, construct straight ditches in preference to winding ditches. The latter erode more readily at the curves and, because of the increased distance, do not take advantage of the available grade.

(3) The grade (percentage of vertical drop of ditch bottom per linear distance) must be sufficient to permit steady flow but not enough to cause erosion due to exces-

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sively rapid flow. A grade of 0.2 percent (0.2 foot drop per 100 linear feet of ditch) to 0.6 percent is usually satisfactory. More grade is needed for a small trickle than for a large flow of water.

(4) Size.- The ditch must be large enough to carry off flood waters but excessively large ditches are to be avoided as they create maintenance problems. A convenient ditch in clay soil and which carries a large amount of flood water as an example, might be 5 feet deep, 6 feet wide at the top, and 1 foot wide at the bottom. In general the smaller the ditch consistent with local conditions, the more efficient it will be from the standpoint of construction and maintenance.

(5) Bottom.- Narrow ditch bottoms, one shovel-width wide, increase the rate of flow and minimize the formation of quiet pools and provide for simpler maintenance. Wider bottoms are sometimes required for large ditches designed for removal of large quantities of water or continuous flow.

(6) Side slope.- The side slope for a ditch in average soil usually need not be more than 1:1 (1 foot horizontal to 1 foot vertical distance or a 45° slope). A slope of 1.5 or even vertical sides may be used in stiff clay or sod soil, whereas a slope of 2:1 or more may be required in loose, sandy soils (Figure 10-14).

(7) Spoil.- Spread the excavated dirt (spoil) in depressions near the ditch, or place in small piles removed from the edges. Never leave the spoil in a continuous ridge along the margin of the ditch as this prevents surface drainage.

(8) Laterals.- Construct laterals, where feasible, instead of several main ditches, to obviate maintenance of a large number of outlets.

(9) Angle of Junction.- Bring ditches together at an angle of about 30° with the direction of flow. A narrow angle tends to cause erosion of the soil between the ditches; a wide angle causes erosion of the opposite banks with silt formation.

(10) Level of junctions.- Bring laterals into the main ditch several inches above the bottom of the main ditch with the drop being graded over a distance of several feet. If these laterals are brought in at the same level as the main ditch, pools are likely to result from silt deposits at the mouth.

(e) Methods of Digging Drain Ditches.

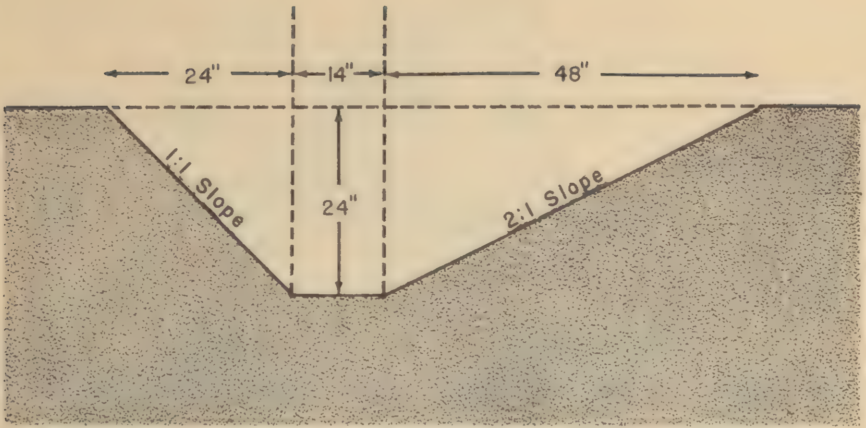


Figure 10-14.--Side slope of a ditch

(1) Hand digging is often the most economical for small ditches, particularly if cheap labor is available. Hand labor is slower than other means but is more accurate.

(2) Machinery such as draglines, ditch digging machines, and marsh plows are more rapid and often more economical than hand labor. The dragline is the most useful machine for digging large ditches. A "right-of-way" must be cleared if the ditch is going through heavy cover, and dragline ditches require "dressing" by hand labor to smooth the sides and bottom.

(3) Blasting is sometimes the most satisfactory method of making ditches, particularly through soft, wet areas containing roots and stumps. The method is rapid and economical, requires little labor, and is more compatible with a camouflage scheme than other methods. The irregularity of the ditch produced, however, often requires considerable hand labor for dressing and maintenance.

(a) The most commonly used explosive is 50 percent nitroglycerine. Dynamite is most effective in wet, clay soil and least effective in sand, especially if dry. Sticks of dynamite or portions of sticks, are placed in holes made with pointed sticks, about 10 to 20 inches apart and usually 4 to 8 inches beneath the surface (Figure 10-15). The smallest ditch that can be economically blasted is about 2 feet deep by 3 feet wide; the largest is about 10 feet deep by 30 feet wide. Approximately 1 pound of dynamite is required to move 1 cubic yard of soft mucky soil. If the proposed site of the ditch is under water. the

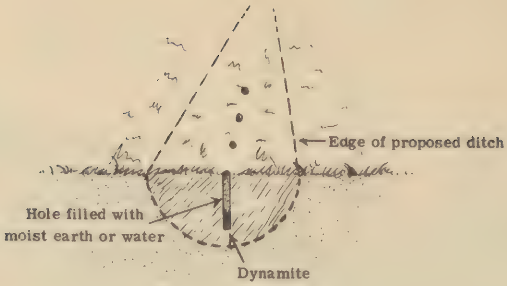


Figure 10-15.--Dynamite ditching

charge required is calculated on the basis of water being equivalent to a similar volume of soil. Small ditches, about 2 feet deep and 4 feet wide may be blasted with half cartridge charges. If the soil is dry, the sticks must be deeper and more closely spaced than if the soil is wet. Deep ditches require heavier charges set further below the surface than shallow ditches. A fuse cap or electric cap with wires leading to a battery or magneto is placed in the first stick in line, the remaining charges being exploded by propagation (sympathetic detonation).

(b) Bangalore torpedoes may be used for ditching in an emergency but the results cannot be controlled as well as with dynamite.

(c) Plastic explosive (compositon C) may be used but charges must be detonated individually.

Caution: Explosives must be handled only by men experienced in their use.

(f) Accessory Devices for Open Ditches. - Several devices are useful to facilitate drainage or to reduce maintenance of open ditches.

(1) Lining.--The ideal permanent ditch is constructed with concrete sides and bottom. The initial cost of a concrete lined ditch is high but maintenance is minimal. Invert linings of concrete may be precast in sections or monolithic poured in the prepared ditch. Expansion joints and weep holes are necessary with concrete if seepage water is present. Rocks, masonry, tile, bricks, asphalt, logs, bamboo poles, or similar material may be used as reinforcement to prevent erosion, particularly at curves. This type of support is called "riprap" (Figure 10-16).

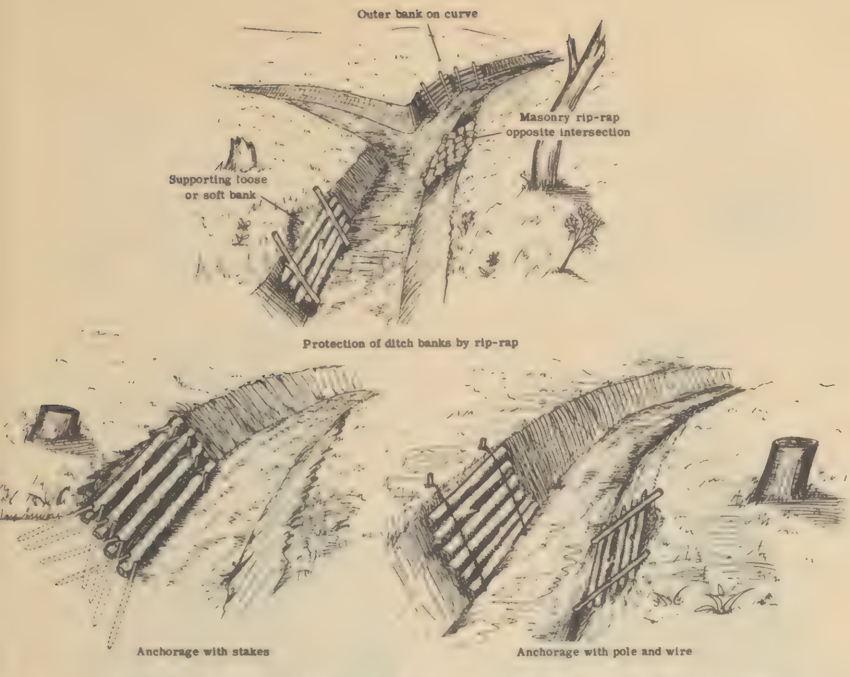


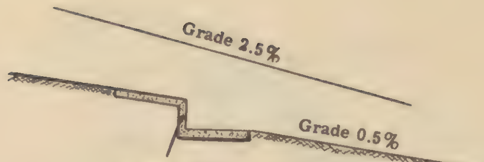
Figure 10-16.--Various types and placement of rip-rap

Sod, or a grass such as Bermuda grass, placed or planted along the banks, provides good support above the water line.

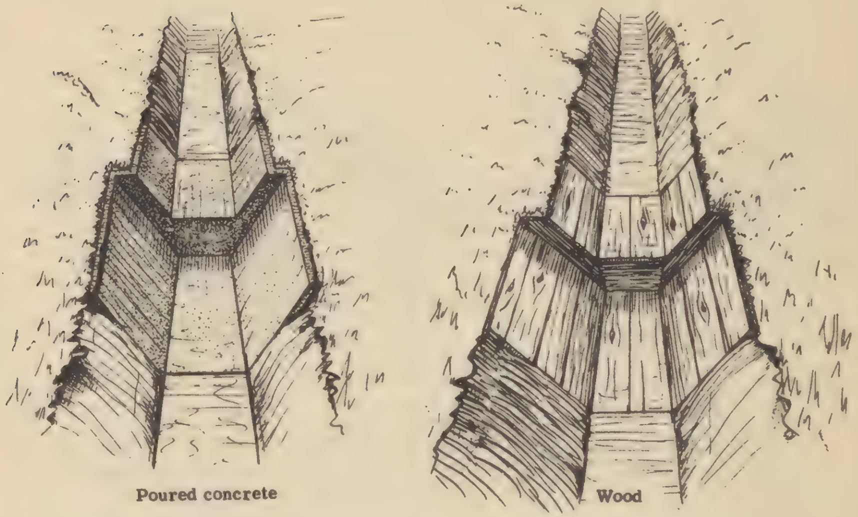
(2) "Steps" are used to reduce the grade of a long ditch without increasing the depth at the upper end. Erosion is prevented at steps by wood, masonry, or concrete splatter plates (Figures 10-17).

(3) Tide gates are structures which permit drainage at ebb tide but prevent return flow during flood tide. They are often used with dykes for reclamation drainage of salt marshes in conjunction with mosquito control. Tide gates may also be used to reduce brackish water mosquito breeding by keeping a marsh flooded with salt water. A simple tide gate consists of a heavy, creosoted wooden flap at the end of a culvert, suspended on galvanized wrought iron pipe by means of galvanized wrought iron or bronze U-bolts, or similar devices (Figure 10-18). Cast iron gates with frames set in reinforced concrete are the most permanent.

(4) Sluice gates serve the same purpose as tide gates for marsh drainage, except that they are manually operated. They may be used for controlled flooding. Sluice gates are also useful for impounding and discharging water in fresh water streams and lakes (Figure 10-19).



Profile of ditch showing use of steps to reduce grade



Poured concrete | Wood

Figure 10-17.--Steps

(5) Dykes and levees in conjunction with tide gates, sluice gates, or pumping are used primarily for reclamation projects but, in connection with mosquito control, may serve to exclude or impound water.

(6) Beach Outfall Structures.--Outfalls discharging into the sea or bodies of water subject to wave action are prone to become clogged with sand deposited by the surf. Sand is often deposited so rapidly in such volume that continual removal is not practicable. Breakwaters extending beyond the surf sometimes retard sand deposition and enable the flow to sweep the channel clear. A spearhead shaped protective structure at the end of an extended channel may retard deposition by preventing direct entrance of waves. Closed culverts extending beyond the point of sand deposition are effective but are more difficult to clear than open channels.

(7) Culverts often increase drainage problems if not properly constructed and placed. They must be sufficiently large to handle floodwaters and should be placed

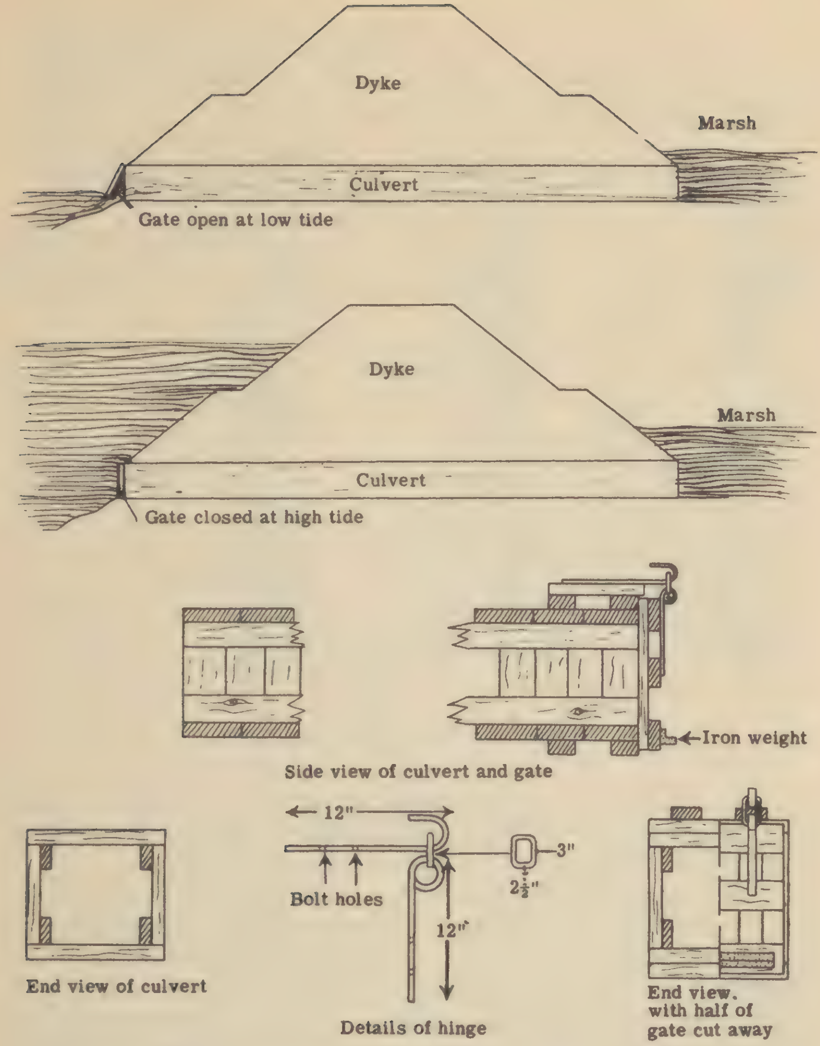


Figure 10-18.--Placement and construction of tide gate

in line with and slightly below the grade of the natural flow. If the upper end is too high, water will be impounded; if too low, the pipe will become clogged with silt (Figure 10-20). If pipe is not available, culverts may be improvised from oil drums with the heads removed.

(g) Subsoil Drainage. - The high initial cost of subsoil drainage prohibits its use in most malaria control work but the method is useful where open ditches are undesirable or impossible to maintain. Sections of butt-joint porous tile

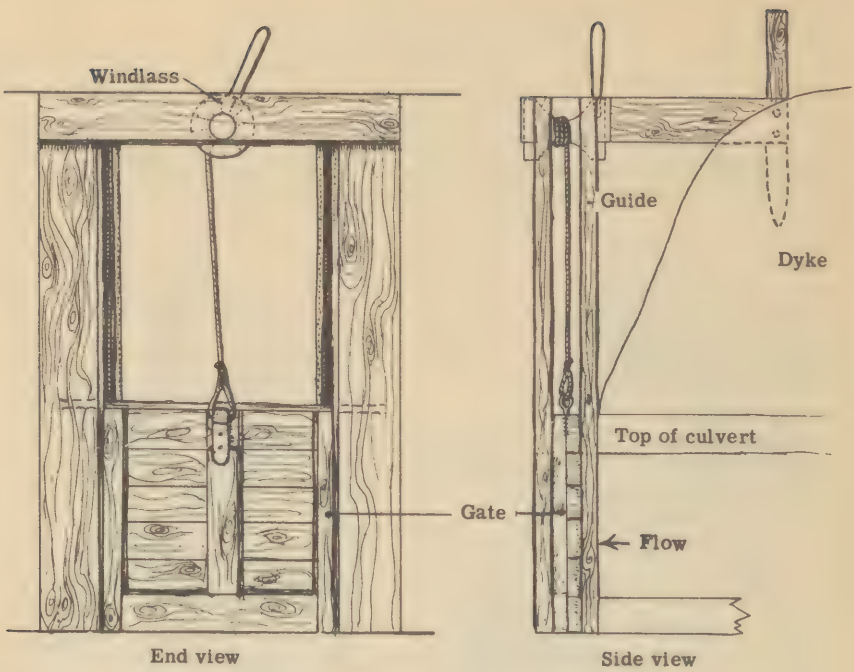


Figure 10-19.--Sluice gate

pipe are laid in a narrow ditch and covered with a porous layer of gravel. Bamboo poles, large rocks, or similar material may be subsituted for tile.

(h) Vertical Drainage. - A method of releasing water held in cup-shaped depressions by an impervious stratum such as hardpan, to a more porous stratum below, consists of digging or blasting a hole or driving a pipe vertically through the impervious layer.

(i) Pumping. - Pumps are used for drainage at or below the water level of the natural outfall, often in conjunction with dykes, levees, and the tide gates. Diaphragm or centrifugal type portable pumps are useful for temporary water removal from small ponds, ditches, canals and excavations for construction work. Permanent pump installations of large capacity are sometimes required for removing water from coastal swamps and marshes which lie at or below sea level.

37. Brush Removal. - Removal of underbrush surrounding a breeding place is often necessary to enable access of larviciding and drainage crews and, in addition, facilitates drying of wet places by promoting air circulation and exposing the area to sunshine. Removal of shade, however, favors sun-loving mosquitoes, and must be kept to a minimum unless sunshine is known to be unfavorable for development of the

species of mosquito being controlled. Machetes, brush hooks, and axes are useful in removing grass and shrubbery. Roots, stumps, and boulders can be removed most efficiently by blasting.

38. Alteration of Breeding Places (Naturalistic Control.) Mosquito breeding is often more easily prevented by modifying the conditions of their breeding than by more obvious methods such as draining or larviciding. It must be emphasized, however, that artificial changes in the natural environment that create conditions inimical to one species may favor breeding of another. Consequently disease-carrying mosquitoes may often be controlled by naturalistic methods only at the expense

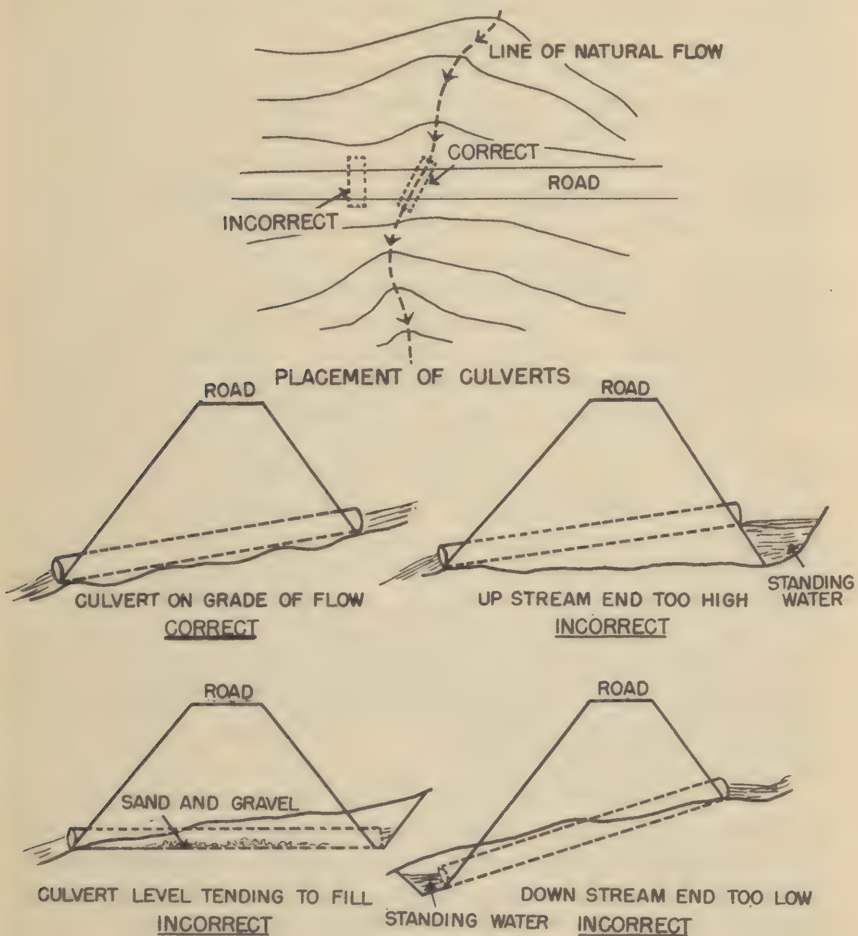


Figure 10-20.--Correct and incorrect installation of culverts

of an increase in pest mosquito breeding. A knowledge of the habits and breeding preferences of all disease-carrying mosquitoes in the area is essential before extensive alterations in the natural environment are undertaken.

(a) Alteration of Light and Shade. - Certain species of mosquitoes can be prevented from breeding by constructing or planting cover over their breeding places, such as along small streams. Others which do not breed in direct sunlight may be controlled by clearing all vegetation covering their breeding places. Preference for light or shade of the species to be controlled should be known before extensive clearings are made to facilitate drainage and spraying.

(b) Clearing. - Vegetation and organic debris provide food for mosquito larvae and protection from natural enemies and decrease the effectiveness of larvicidal work. Clearing the water of surface growth often removes an important feature of the larval habitat and facilitates the distribution and spread of larvicides. The herbicide 2, 4D, (2, 4 Dichlorophenoxyacitic acid) has been used successfully in the removal of water hyacinth, but it should not be used in watershed areas. More than 2-3 parts per million affects the taste of drinking water. Leaves, grass and brush resulting from clearing operations must not be thrown in the water ordinarily, however under special conditions the lowering of pH by purposely introducing large quantities of organic matter may successfully prevent breeding of mosquitoes which prefer neutral or high pH water.

(c) Alteration in Salinity. - Breeding of fresh or brackish water mosquitoes in landlocked tidal pools or lagoons which tend to become fresh from rain or stream water can be prevented by opening a channel to the sea to permit flushing with salt water. Conversely, exculsion of salt water, in circumstances where the swamps are normally fresh, will prevent breeding of salt water species. Salinity control frequently requires a specialized form of outfall structure such as a breakwater or a culvert to prevent blocking of open channels with sand by wave action, tide gates to permit flow in only one direction, or sluice gates (Figure 10-19) dykes, and pumps for controlled water transfer.

(d) Fluctuation of water level in reserviors and lakes by means of dams and sluice gates discourages plant growth in which larvae breed at the water margins and exposes the larvae to fish and to wave action. Changes are controlled to take place at intervals of less than the developmental time of the aquatic stages of mosquito development.

(e) Damming may be used to facilitate stream flushing or to convert swamps into lakes in which breeding may be more

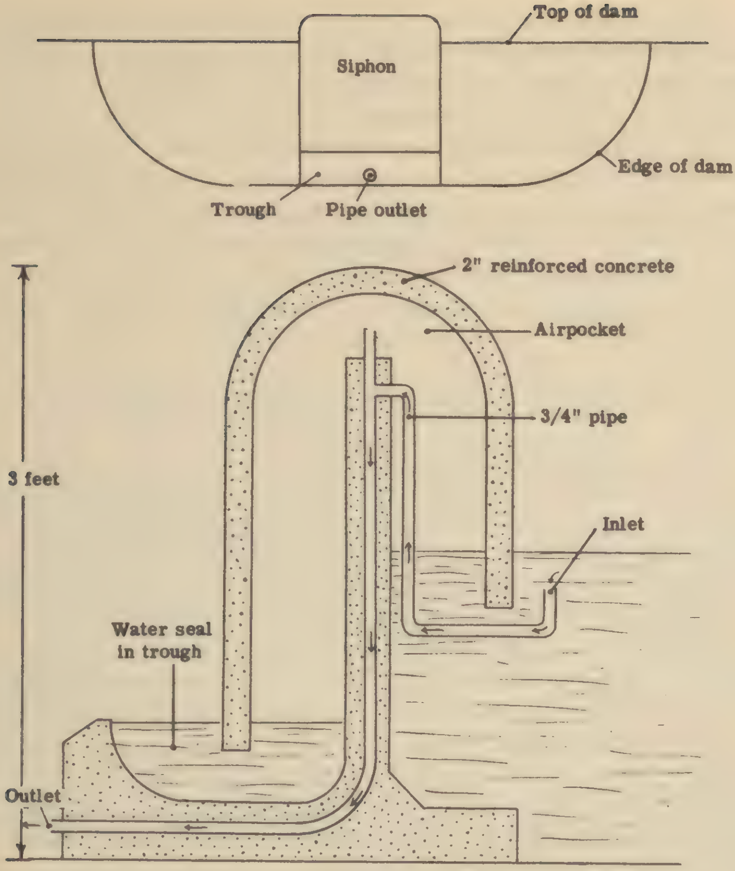


Figure 10-21.--MacDonald siphon

easily controlled by applying insecticides or by periodically changing the water level.

(f) Flushing of small streams periodically by means of dams and sluice gates or automatic siphons (Figure 10-21) prevents breeding by washing away larvae and pupae.

(g) Irrigation control, consisting of alternately drying and flooding, is employed to control anophelines in fields of rice and similar crops. Alternate use of ditches has also been effective.

(h) Controlled flooding of extensive salt marshes may be used to prevent production of salt marsh mosquitoes. The marshes should be flooded long enough for the brood to hatch; drainage should be effected before adults can emerge the procedure washing larvae and pupae out to sea. The draining must take place during a two or three day period and remaining pot holes must be larvicided.

(i) Pollution. - As some disease-carrying mosquitoes, particularly certain anophelines, prefer clear water, pollution of the water with refuse, leaves, weeds, or brush can be used in the control of such species.

(j) Natural Enemies. - Introduction of top-feeding minnows is often effective as a supplementary means of reducing mosquito larvae in small water containers, reservoirs, ponds, stream pools, and wells. The common top minnows, Gambusia and the killifishes, Fundulus, are the most widely used species. Minnows are seldom, if ever, completely effective and no reliance should be placed on the method.

Section VIII.--CONTROL OF MANSONIA MOSQUITOES

39. Important Factors in Control of Mansonia. Mansonia mosquitoes are of potential military importance as vectors of filariasis. They are peculiar in habits and particular skill is required in detecting and controlling them. The larvae upon hatching descend beneath the surface and attach themselves to stems and roots of aquatic plants by inserting the tip of the air tube, specialized for the purpose, into the plant tissues from which they obtain air. The larvae and pupae remain attached in this manner until ready for the adult to emerge. They then rise to the surface where they remain only long enough for the adult to work out of the pupal skin. The floating aquatic plants, Pistia and Eichhornia, which are found in ponds, lakes, and slowly flowing streams throughout the tropics, are among other common host plants.

40. Detection. - It is almost impossible to locate the larvae by ordinary inspection methods. Where they are attached to floating plants, a pan may be brought up underneath them and the plants and larvae lifted, or the plants may be quickly transferred to a pan of clear water for examination. In the case of certain species which attach themselves to plants rooted to the bottom, agitation of the plant may cause the larvae to detach themselves, necessitating examination of samples of bottom mud placed in pans of clear water.

41. Methods of Control. - Elimination of the breeding places by filling or draining and destruction of the host plants is the most effective control method. Larvicides, such as oil or DDT-oil solutions, on the surface of the water are not effective unless applied frequently enough to maintain a permanent film, since the pupae must be killed during the short time they remain at the surface for the adults to emerge. DDT emulsion is toxic to a depth of three feet when applied to the surface of water at the rate of 1 pound of DDT per acre, and

should, therefore, be effective against larvae and pupae attached to submerged roots and stems if applied frequently and in heavy doses. Because of the difficulty of controlling Mansonia mosquitoes with larvicides, the effectiveness should be evaluated by inspections at frequent intervals. Chemical weed killers may be used to eradicate certain host plants.

Section IX.--CONTROL MEASURES FOR MISCELLANEOUS BREEDING PLACES

42. Small Containers. - Discarded tin cans, empty coconut husks, and similar articles which collect water are important sources of mosquitoes, particularly those with domestic habits which carry yellow fever, dengue, and filariasis. Disposal of such items by burning or burial is usually more satisfactory than finding and treating each individual breeding place.

43. Domestic Water Containers. - Barrels, watering troughs, water buckets, and water jars in native habitations are troublesome breeding places for the domestic disease-carrying mosquitoes. Periodic emptying each week or 10 days is effective but requires a great deal of time and labor. The small predatory fish Gambusia, may be used in water kept for domestic use.

44. Wells and Cisterns.

(a) These breeding places require special treatment since larvicides which render the water unsuitable for drinking must not be used. Carefully fitted covers, either solid or screened, will prevent mosquito egg laying. DDT should be impregnated into burlap or cloth covers of cisterns and rain barrels, and is effective against larvae in abandoned wells and similar water collections, but it must not be employed in water used for drinking or cooking. Kerosene or Kerosene pyrethrum sprays applied lightly to the surface of the water are less objectionable than oil sprays.

(b) A few drops of nonleaded gasoline on the surface of the water will kill larvae and pupae. It evaporates in a few hours but should not be used in metal water containers inasmuch as metal retains an unpleasant taste which it imparts to water subsequently used.

(c) Minnows are useful in wells, cisterns, reservoirs, and other large containers of water for domestic use.

45. Axils of Plants. The axils of such plants as sago palms, banana-like trees, and epiphytic plants like bromeliads may present serious problems when harboring mosquitoe larvae. Destruction of the plants by cutting is usually simpler than larviciding. Spraying DDT from an airplane is simple

and effective, and economical if the area to be controlled is large. However, many such plants breed non-biting mosquitoes. Before undertaking expensive control measures involving treatment or destruction of these plants it is essential to determine whether disease vectors are actually breeding therein.

Section X.--MOSQUITO CONTROL ABOARD SHIP

46. Protective Measures. - Ships in foreign ports require protection from disease-carrying mosquitoes unless anchored beyond the flight range of mosquitoes, usually a mile or more in the case of anophelines. Screening must be placed over portholes, hatches, and other openings while in ports where mosquitoes are a hazard, and precautions must be taken to protect personnel who are on deck watch, or otherwise exposed to mosquitoes, with repellents and nets. The commanding officer must not permit men on deck after sundown in malarious ports unless so protected and, when personnel are on liberty or ashore on duty, precautionary measures must be taken in conformity with local regulations.

47. Disinsection.- Large malaria-free areas exist in various parts of the world due to the absence of anopheline mosquitoes. The introduction of anophelines into these areas must be avoided, both for the protection of the native population and naval personnel. All surface craft, including cargo ships that are or may come under the authority of the Navy Department, should be disinsected when practicable prior to arrival at a malaria-free port from a known endemic area, except from North or South America, unless deemed inadvisable by the commanding officer. Adult mosquitoes will be killed by thoroughly spraying cargo holds, living spaces, and other confined spaces with the aerosol insecticide at the rate of 1 lb. per 100,000 cu. ft., (405 sec. per 1000 cu. ft) of closed space. Standing water in containers of any kind must be frequently inspected or changed.

48. Mosquito Control Aboard Aircraft.- The possibility of transporting dangerous mosquitoes and other disease-carrying insects by aircraft is a hazard due to the speed and volume of travel. Aerosol insecticide should be used for spraying aircraft as well as surface craft, upon leaving a port having an outbreak of malaria or dengue fever and prior to arrival at a disease-free port from an endemic area. Aircraft entering the U.S. must be disinsected in accordance with regulations and directions in Circular Letters of the Medical Department and current directives.

Section XI.--INSECTICIDE MATERIALS AND EQUIPMENT FOR MOSQUITO CONTROL

See Chapter 8 Section V

Aerosol Gas (1 pound cylinder) Catalog of Navy Material Nos. 51-G-120-51.

Aerosol Empty Cylinder (1 pound capacity) Catalog of Navy Material Nos. 51-C-2031-10.

Aerosol Empty Cylinder (40 pound cylinder with charging connection for refilling dispensers) Catalog of Navy Material Catalog No 51-C-2031-25.

Aerosol Gas (40 pound cylinder) Catalog No. 51-G-120-70.

Bed Nets (1 per man.) Catalog of Navy Material Catalog No. 27-B-340.

Cotton Gloves (1 laor 1er ,am). Federal Standard Stock Catalog No 73-G-16970 (Ship's Store item)

Head Nets, Black, camouflaged, and white. MarCorps Stock Nos. 27-H-180 (Black) - 182, (Camouflaged) - 184 (white).

DDT insecticide Concentrate Powder (commercially pure DDT in 5 pound and 25 pound airtight cans).

DDT Insecticide Concentrate Solution (DDT-xylene-emulsifying agent in 5-gallon cans). Catalog of Navy Material No. 51-I-157-500, - (Fire hazard See Chapter IX, Section II).

DDT Insecticide Diluted Powder (10 percent DDT in talc in 5 and 25 pound cans). Catalog of Navy Material Nos. 51-I-157-600-610.

Duster, Insect, Hand, Rotary Blower Type (5-10 pound capacity) 41-D-4530.

Sprayer, Insect, 3 gal. cylinder type, Catalog of Navy Material No. 41-S-4125.

Sprayer, 3 qt. continuous spray 41-S-4120.

Sprayer, 50 gal. gasoline engine driven with double outlet, 4-50 ft. lengths of oil resistant hose, insecticide nozzles. Catalog of Navy Material No. 40-S-2590-18.

Kerosene (in bulk, 55 gallon drums and 5 gallon cans, respectively). Federal Standard Stock Catalog Nos. 7-K-500 (new no.) vvk not odorless, 7-K525 and 7-K505 respectively.

Fuel oil, Diesel No. 2, Cetane 45 preferred. Fed. Stock Catalog No. 7-0-145 (bulk 7-0-145-5 (5 gal. cans); 7-0-145-55 (55 gal drums).

Laboratory Equipment, Components G17, (Malaria control), G18, (Epidemiology) and G19, (Malaria and Epidemic control), units:

Leggings khaki duck (1 pair per man). Stock Nos. 72-L-71100 71102, 71104, 71106, 71108, 71110, Size 1; 2; 3; 4; 5; 6; 81156, 7; 81157, 8; 81158, 9.

Other Field and Heavy Equipment. Construction battalion sanitary units and sanitary blocks:

Repellent (2-ounce bottles). Three bottles per man per month allowed in malarious areas. Catalog of Navy Material No. 51-D-237-400.

Chapter 17

Disinfection and Fumigation

Section I.--DEFINITIONS

1. Disinfection is the destroying or killing of the agents responsible for infections.

2. Sterilization is the killing of all microbial life on the surfaces and within an object or material. Sterilization always disinfects, but disinfection may not sterilize.

3. Concurrent disinfection entails the immediate disinfection and disposal of all infected material during the course of an infectious disease. The disinfection of all infected discharges and all articles soiled by them is carried out. The use of ultra-violet radiation, the oiling of floors and blankets are under active investigation at present to determine their efficiency and practicability as methods of purifying and cleansing the atmospheric environment to check the spread of infectious agents. Objects or materials needing disinfection are discharges from the body (sputum, urine, feces, pus, etc.), towels, hankerchiefs and fabrics, food, tableware, objects put into the mouth, hands or other unprotected portions of the body.

4. Terminal disinfection refers to the final measures of disinfection taken after recovery or removal of a case of communicable disease. A general disinfection and cleansing of person, apparel, and environment is undertaken.

5. Germicide is a term synonymous with disinfectant and means a substance or agent which destroys germs.

6. An antiseptic inhibits or restrains the growth of microorganisms without necessarily destroying them (a bacteriostatic agent.)

7. Asepsis means freedom from or absence of living harmful micro-organisms.

8. A deodorant eliminates the cause of, or neutralizes objectionable odors. However, many deodorants are not disinfectants. Cleanliness is the best deodorant.

9. Fumigation denotes the use of fumes or gases to kill vermin, insects, rats, mice and other small animals acting as vectors of infection or destroyers of food and other materials.

Section II.--SOME PRINCIPLES OF DISINFECTION

10. An ideal disinfectant would have the following qualities: (a) a potent germicidal effect, (b) not easily made ineffective by contact with organic matter, (c) chemical stability, (d) soluble in water or forming a stable emulsion, (e) not poisonous to man or higher animals, (f) penetrative power, (g) non-corrosive, non-bleaching, not rotting or staining, (h) inexpensive. Disinfection is essentially a chemical reaction and is subject to the general laws effecting such reactions. Thus, heat hastens the speed of disinfection. The use of warm or even hot solutions of disinfectants is usually recommended in practice. Time for the disinfectant to penetrate, make contact with the viable agent and then to kill, is necessary. Frequently, the breaking up or disintegration of the material to be disinfected speeds the completion of the process. Generally an emulsified disinfectant has greater germicidal power than a solution of the same concentration because of more effective contact.

Section III.--PHYSICAL AGENTS FOR DISINFECTION

11. Of the physical agents for disinfection, heat has the widest practical applications. The various forms in which it is employed are:

(a) Burning.

(b) Dry heat--160 degrees C. for 1 hour kills even most resistant spores.

(c) Boiling.

(1) 100 degrees C. for 1 hour kills everything except tetanus, anthrax and other spores.

(2) Boiling in 3 to 5 percent phenol for 30 minutes kills spores.

Note: The addition of 1 percent sodium carbonate to boiling water when disinfecting bright steel objects or cutting instruments prevents rusting and injury to cutting edge.

(d) Steam sterilization is accomplished by:

(1) Streaming steam for 30-60 minutes.

(2) Steam under pressure -- 15 lbs. (121 degrees C.) for 30 minutes.

Section IV.--CHEMICAL AGENTS FOR DISINFECTION

12. A wide variety of chemical disinfectants is available, of which none is ideal. The selection of the most suitable chemical agent for effective disinfection requires consideration of the advantages and disadvantages of the disinfectant with relation to the character of the material or space to be disinfected.

13. Quarternary Ammonium Germicides.

Although quarternary ammonium compounds are several times as costly as coal tar disinfectants, their killing power has won for them an assured place in the field of sanitation. These compounds are comparatively nonirritating, noncorrosive, and nontoxic, therefore, they are preferred to other materials lacking these properties.

One of these quarternary compounds, marketed under various names is a mixture of alkyldimethylbenzylammonium chlorides. It is supplied to the Navy as "Disinfectant, germicide and fungicide solution." Stock No. 1-169-358.

For general disinfection a 1:200 dilution of standard strength solution should be used. Articles for general disinfection embrace; dishes, glassware, towels, linen, toilets, urinals, rooms where contagious disease has been treated, and so forth. A 1:40 dilution of standard strength solution is excellent for the sterilization of rubber goods, surgical and barber instruments, and as fungicide and so forth.

14. Bichloride of mercury is a potent, widely used germicide. Its disadvantages are that it corrodes metals, forms insoluble and inert compounds with albuminous matter and is very poisonous to man and animals. It is frequently used in a dilution of 1:1000. At this strength with direct contact for 30 minutes or more it kills all vegetative forms of bacteria. A dilution of 1:500 in direct contact with spores for at least 60 minutes kills them. A 25 percent solution in alcohol, with added HCl, NH_4Cl, or other chloride to prevent precipitation, keeps well.

15. Merthiolate, metaphen, and phenyl mercuric nitrate are less toxic than bichloride of mercury, but their bacteriostatic power is high. Mercurochrome is antiseptic but not a very potent germicidal agent. The first three are good skin disinfectants.

16. Copper sulfate is a relatively weaker germicide than bichloride of mercury but is highly specific for algae; a dilution of 1:1,000,000 will kill most species of algae.

17. Ferrous sulfate has only feeble germicidal power, but is a good deodorant.

18. The zinc salts, such as zinc chloride, are weakly germicidal.

19. The disinfecting power of the coal tar products depends upon the phenols and cresols they contain. Phenol, the standard against which other disinfectants are measured, is soluble in 10.6 parts of water at 25 degrees and very soluble in ether, alcohol, chloroform, benzol, carbon disulfide, glycerin, and fixed and volatile oils. However, when dissolved in alcohol or ether it loses germicidal value. It is a corrosive poison. Materials to be disinfected by phenol should be exposed to a 3 to 5 percent solution 30 to 60 minutes. Spores are killed with certainty by boiling for 30 minutes in 3 to 5 percent phenol solution. The introduction of a halogen atom into the benzol ring greatly increases the germicidal power of phenols, cresols, and naphthols with a concomitant decrease in toxicity. Tri-brom-Beta-naphthol and tri-chlor-Beta-napthol are powerful germicides, practically odorless and not very poisonous. Organic matter interferes with their action.

20. Carbolic acid, which consists of a mixture of crude phenols and cresols, is very useful and widely employed. It is soluble in 15 parts of water at 15 degrees C. equaling at 6 percent solution. The undissolved portion should not exceed 10 percent of volume of carbolic acid; 2.5 to 5 percent solutions destroy non-spore-forming bacteria with 30 minutes of exposure.

21. Cresol is effective 1 percent solution. It is soluble to the extent of 2 1/2 percent in water. It readily forms excellent emulsions, has a higher germicidal value than phenol or carbolic acid and is less poisonous.

22. Saponified cresol and lysol solutions should not contain benzophenol, which is extremely toxic to tissues.

23. Coal tar creosote, a highly complex liquid obtained from destructive distillation of wood or coal, contains phenols and cresols.

24. The oxidizing agents such as potassium permaganate and hydrogen peroxide have limited application because they are easily reduced and rendered inert by organic matter.

25. The disinfecting power of acids is dependent upon the hydrogen ion concentration. Some acids, such as salicylic,

benzoic and boric have negative radicals that are germicidal. In the series of formic, acetic, propinzoic, butyric and valerianic acids the bactericidal power increases and surface tension decreases with increase in molecular weight. Because of boric acid and the borates are used to preserve food and drink.

26. The principal alkalis of use as disinfectants are lye (sodium hydroxide) and lime (calcium oxide.) High-test commercial lye is a suitable germicide for use in barns and stables--particularly against Brucella abortus and related organisms. It is inexpensive, odorless, and efficient. Many caustic washing compounds consist of sodium chloride, sodium carbonate or tri-sodium phosphate added to sodium hydroxide to increase the germicidal activity. (See Chapter I, Messing Sanitation and Rations.)

27. Lime is considered one of the best and cheapest disinfecting, deodorizing, and drying substances. Calcium oxide, unslaked is caustic; calcium hydroxide is slaked lime, and is less active. A 1 percent solution of lime kills non-spore-forming bacteria within a few hours. A 3 percent solution kills typhoid bacilli in 1 hour. A 20 percent suspension added to equal parts of feces of filth and mixed,disinfects in 1 hour. Whitewash, which is useful in cellars, privies, barracks, poultry houses, and rough structures, generally is slaked lime mixed with water plus a mordant (glue, sugar, or rice flour) to cause adherence.

28. Of the group of halogens, chlorine, hypochlorous acid, the hypochlorites, and the chloramines are commonly used for disinfection.

29. Chlorinated lime (bleaching powder, calcium hypochlorite) --According to U. S. Pharmacopeia it should contain not less than 30 percent of available chlorine. Five-tenths (0.5) to 1.0 percent of water solution kills most bacteria in 1 to 5 minutes. A 5 percent solution usually destroys spores in 1 hour. It bleaches and is destructive to fabrics. Promptly rinse treated fabrics in plenty of fresh water to prevent damage. It is alsc a deodorant and dessicant. A 5 percent solution is recommended for disinfection of excreta of the sick.

30. Labarraque's solution is an aqueous solution of several chlorine compounds, chiefly sodium hypochlorite and sodium chloride. It should contain at least 2.6 percent by weight of available chlorine. In practice, diluted 1 to 4 with water, it is mainly used for disinfection of the person in surgery.

31. Dakin's solution. Active ingredient is sodium hypochlorite. Must be freshly prepared and be free from caustic

alkali. The concentration must be exactly between 0.4 and 0.5 percent, for below that point it is not active and above, it is irritating. It must be protected from light (decomposes.)

32. Bromine and iodine are very potent germicides. A 2 1/2 percent iodine solution is usually sufficiently strong. A watery solution is stronger than alcoholic solutions (tincture) but the latter penetrates better.

33. Alcohol. Germicidal power of alcohol is pronounced. It is a good preservative because of its bacteriostatic power. A 50 to 70 percent solution is best. However, spores are not affected even at these concentrations of alcohol.

34. Soaps have limited germicidal power. Their mechanical effect predominates. Fatty acids are apparently the active principles for disinfection.

35. Formaldehyde solution (formalin) is a very valuable disinfectant with a wide range of usefulness. It is a deodorant, not very poisonous and not injurious to most articles. It usually consists of a 40% solution of formaldehyde (gas) (HCHO) in water, which has an irritating odor and is unstable chemically. A 10 percent solution is equivalent to a 1:520 solution of bichloride of mercury but stronger than 5 percent carbolic acid solution. A 10 percent solution on contact for 1 hour disinfects feces. It is used to disinfect urine, excreta, sputum, thermometers, instruments, precious articles, antiques, and objects of considerable value.

Section V.--FUMIGATION

36. Gases as disinfecting agents are uncertain, unreliable, and lack power of penetration.

37. Formaldehyde is generally useful and one of the best disinfecting gases. It diffuses slowly and has a specific gravity approximately equal to air. For successful disinfection a large volume of gas in a short time under correct conditions of temperature and moisture is necessary. It is germicidal, nonpoisonous, not destructive, and a deodorant. A 6 to 12 hour exposure, in small tight spaces, to strong concentrations of the gas is necessary to achieve surface disinfection. It is released from a watery solution by potassium permanganate (60 percent of gas liberated), by bleaching powder (25 percent) and sodium dichromate (30 percent). Efficient formaldehyde fumigation requires a moist atmosphere. Most molds are quite resistant to formaldehyde.

38. Sulfur dioxide is too destructive for fabrics, colors, and metals for common usage. It is a better insecticide than germicide. It is used to fumigate holds of ships, cellars, sewers, stables, etc.

39. Hydrocyanic acid gas (HCN) and cyanogen chloride (CNCl) are very poisonous to man and animals. They are effective for destruction of vermin on board ships, in warehouses, greenhouses, granaries, railroad cars, and so forth. They have no germicidal power and the strictest precautions are necessary in their application.

(a) Zyklon-B is liquid hydrocyanic acid (gas) absorbed by diatomaceous earth and packed in strong containers under a vacuum. For use, the can is opened and the gas-containing earth sprinkled on floors, 2 hours' exposure time is allowed for an empty ship; 4 hours with cargo aboard.

(b) HCN discoids consist of wood pulp disks with 2 1/4 times their weight of absorbed hydrocyanic acid gas; 5 percent of chloropicrin has been added as a detector.

(c) The spraying of liquid hydrocyanic acid gas compressed in steel cylinders may become more widely used.

(d) Cyanogas A-Dust is a finely divided powder of calcium cyanide which, on contact with the moisture in the air, evolves hydrocyanic acid gas. It must be used with the same careful precautions always necessary in handling hydrocyanic acid gas. Cyanogas A-Dust is adapted for use in the Cyanogas foot pump to fumigate rodent burrows. The hydrocyanic gas is released in the burrows killing the rodents and their ectoparasites. Cyanogas is also useful outdoors in the extermination of ant nests and collections of fleas. A complete instruction pamphlet is enclosed in each can or drum of the calcium cyanide (Cyanogas). Cyanogas may be obtained by requisitioning calcium cyanide in 5 pound cans through Supply Department channels under Stock No. 51-C-418; the foot pump with 5-pound reservoir, under stock No. 41-D-4525.

(e) Fumigation by hydrocyanic acid gas is conducted by the U. S. Public Health Service when, in the opinion of the commanders of Forces Afloat, conditions on board are considered such as to make fumigation by this process necessary. The cost of the materials used by the Public Health Service for fumigating Navy ships has to be borne by the Navy Department. Fumigation with HCN on board ships will be undertaken only in accordance with Chapter 36, BuShips Manual.

(f) Hydrocyanic acid gas fumigation is very effective but the process had marked disadvantages. The gas is extremely poisonous and its use ordinarily requires the abandonment of the vessels for a more or less protracted period. It can be

used only by experienced personnel. In some localities it has been necessary for the Navy to maintain a stock of this material for use by the Public Health Service in fumigating naval vessels.

40. Carboxide Gas.

(a) Carboxide gas is an effective insecticidal fumigant, and of sufficiently low toxicity that it could be satisfactorily applied aboard ship by naval personnel if proper precautions are taken. It is not to be used except in special circumstances for control of flour moths and bean bettles in storerooms; and in those instances where fumigation for rats is urgent and Public Health Service personnel are not available to perform fumigation with cyanide. Fumigation shall not be used on naval vessels for with cyanide. Fumigation shall not be used on naval vessels for insect eradication except under the above conditions. Carboxide gas shall not be carried on board naval vessels as a part of regular allowance equipment. When required, it should be obtained, by requisition on the nearest Navy yard or station.

(b) The carboxide gas is delivered in steel cylinders of 30 and 60 pound capacity. In ordering, consideration should be given to the capacity of cylinders which can be most advantageously and economically utilized in the spaces to be fumigated. The cost of the carboxide, when obtained, will be chargeable to the ships' regular quarterly construction and repair allotments.

(c) Composition and physical properties: 10 percent of ethylene oxide and 90 percent of carbon dioxide, both components being 1.5 times as heavy as air. The ethylene oxide is the insecticidal fraction; the carbon dioxide renders the mixture noninflammable. The carbon dioxide also markedly accelerates the respiration of the insects and hence renders the ethylene oxide more effective by increasing the speed of its absorption by the insect. The pressure of a full cylinder is 725 pounds per square inch at 70 degrees F., the mixture issuing as a liquid breaks down to a fine mist and completely vaporizes within a few minutes. The gas has a faint but distinct etherlike odor easily recognized in the concentration set up for fumigation and is noninjurious to clothing, gold braid, furniture or food products.

(d) Concentrations: Six pounds per 1,000 cubic feet for an exposure period of 3 hours is based on the gross cubical contents.

(e) Hazard for man: The hazard in the concentration set up for fumigation is comparatively slight as compared with hydrocyanic acid gas, the toxicity as estimated from animal

experiments being only about one-fiftieth of that for hydrocyanic acid gas. There is, however, risk of headache, nausea, and vomiting if personnel violate the simple precautions outlined hereunder in regard to entering of spaces inadequately aerated following fumigation. Death has resulted from the failure to use oxygen rescue-breathing apparatus.

(f) Closure of ship's spaces: Closure should be as airtight as possible in order to reduce leakage of carboxide to a minimum. This should be quickly accomplished for watertight compartments.

(1) Ventilating system (supply and exhaust): Ventilating ducts should be disconnected at the point of entrance to compartments, wherever practicable, and the watertight covers applied. Otherwise, the dampers of all terminals must be closed and the louvers plugged with damp rags or waste.

(2) Special measures: Commercial masking tape should be utilized for the sealing of door seams and various cracks and crevices. It adheres effectively and leaves no residue on removal. Masking tape should be equivalent to that manufactured by the Minnesota Mining and Manufacturing Company, St. Paul, Minnesota. It should be obtained in rolls 2 inches wide and 60 yards in length. The quantity needed will naturally be dependent on the conditions encountered. An average estimate would be one roll of masking tape per 60 pounds of carboxide required. Wrapping paper coated with engine grease or vaseline sealed at the edges with masking tape is satisfactory for the closure of larger openings such as door louvers, the grill work of staterooms, and food emergency by strips of ordinary paper and starch paste, but the application is time consuming and requires extensive cleaning to remove the material.

(g) Diffusion: Proper diffusion of the fumigant throughout the space or spaces is essential. This will be accomplished by the operation of ordinary fans alone, or combined with portable ventilating sets.

(h) Open flame heaters or exposed element electric heaters should not be used in areas being fumigated. In the presence of relatively high temperature, such as may be locally produced by such devices, the ethylene oxide content of carboxide may break down chemically, lose its fumigating properties, and create a condition of inflammability not existent in the original fumigant. This hazard is not involved in the use of electrical circulating fans or portable ventilating sets to promote diffusion of the fumigant throughout the area. Special carboxide vaporizing nozzles should always be used. Under no circumstances should rubber tubing or rubber hose be used

with carboxide. Any added connections must be of metal and suitable for working pressures of 800 pounds per square inch.

41. Instructions.

(a) Preparation for fumigation:

(1) Penetration: Open wide all locker doors, furniture drawers, file cases, etc., and remove covers from mattresses and pillows in order to facilitate maximum access of the fumigant.

(2) Ventilating system: Stop and seal as indicated above.

(3) All openings sealed: Seal any openings which might permit gas to escape. Utilize masking tape or a combination of greased paper and masking tape, for magazine vents, voice tubes, radio leads, enunciator chain leads, non-water-tight doors, natural ventilators, and so forth. Close all drains in heads and bathrooms. Dog down all watertight doors and air ports.

(4) Diffusion: Start all fans in space or spaces to be fumigated. If desired to further facilitate diffusion, also utilize portable ventilating sets so arranged as to make suction from areas tending to contain dead air. This arrangment will also facilitate aeration following fumigation.

(5) Handling of carboxide cylinders: Determine the cubical content of the space or spaces to be fumigated. Calculate the weight of carboxide required on the basis of 6 pounds per 1,000 cubic feet. There is no objection to exceeding this concentration of the fumigant except the additional cost and greater time required for aeration. Place the cylinders and so direct the nozzle as to effect the maximum concentration of the gas at the beginning in the area known to be infested. Carboxide may stain fabrics or painted surfaces if projected directly on them. Accordingly, when being discharged, the cylinders should be so located and secured as to prevent the carboxide's striking directly any fitting or structure within 5 feet of the gas outlet. Securely lash all cylinders in an upright position as the violent discharge of the contents tends to unbalance the containers. Cylinders must be grounded before discharging gas in order to avoid static sparks. In case the cylinder is standing on linoleum or other insulating deck covering, grounding may be effected through wire lashing to a bulkhead or to metal furniture which in turn is grounded to some metal structure of the ship. Make certain that all personnel in the area are accounted for. Test all cylinder valves in advance in order to be certain that there is not resistance to opening by hand. In some cases a wrench may be necessary. When all preparation is complete and all openings

to the space closed except the exit, open wide the valves of the cylinders successively, beginning with the unit farthest from the point of exit and with the nozzle directed away from the operator.

(b) Aeration after fumigation: Open the area fumigated at the end of 3 hours. Detail personnel wearing oxygen rescue breathing apparatus to open all airports or other connections to the outside air and reestablish supply and exhaust ventilation. Maintain fans and portable ventilating sets in operation during the period of aeration. The time for adequate aeration will necessarily vary according to the status of the ventilation, both natural or artificial, of the various parts of the area fumigated. It will ordinarily be safe for personnel to enter for their normal activities 2 hours after full ventilation has been in progress. This period, however, should be determined by the officer in charge of the fumigation in conjunction with the medical officer. Particular care should be taken to clear spaces containing dead-air pockets where the odor or carboxide tends to persist. Storerooms or other poorly ventilated spaces should not be entered until the following day.

(c) Precautions for personnel:

(1) Working party: Members of the working party detailed to open carboxide cylinders or to handle details connected with clearing of the area of gas after fumigation shall wear oxygen rescue breathing apparatus. There is risk of serious symptoms or death unless this precaution is used.

(2) General Personnel: The personnel in general will not be permitted to resume their normal activities in the space or spaces following fumigation until so authorized by the fumigating authority.

42. Fumigation of clothing and equipment with methyl bromide or steam have been superceded by using DDT. (See chapter 9.)

43. Paradichlorobenzene (PDB). - This compound may be considered as a fumigant in the sense that its fumes repel flies. It is useful in the control of flies in latrine pits or other enclosed spaces containing substances which readily attract flies and are favored breeding places. Forfurther information concerning use of paradichlorobenzene consult chapter 9.

44. DDT insecticide has eliminated the need for all of the various dangerous gases formerly employed for insect pest control in ships and shore stations of the Navy. Residue spraying of DDT is the most effective means of bedbug extermination aboard ship and in living quarters ashore, replacing fumigation with hydrocyanic acid, methyl bromide, or carboxide gases. DDT has the special advantage of remaining

effective against bedbugs over a period of 6 months or longer. DDT is largely replacing other methods in the control of fleas, lice, and roaches. (See Chapter 9.)

Section VI.—CONTROL MEASURES OTHER THAN FUMIGATING

45. A $2\frac{1}{2}$ percent DDT spray made with water-dispersible DDT powder has been found effective in treating warehouses where food products are stored. It is applied to bulkheads and wood work at a rate of 1 gallon to each 1,000 square feet. Contact with the DDT will kill weevils and other insect pests of stored grain as they crawl on the treated surfaces. Precautions must be taken to avoid contamination of food products when applying spray.

46. Several species of small beetles and moths infect subsistence supplies such as rice, oatmeal, breakfast cereals, grain, meal, peas, beans and dried fruits. The most important insects infesting these supplies are flour beetles, grain and flour moths, pea weevils and bean weevils. Much of the food is destroyed, but in addition, it is often rendered undesirable for human consumption due to contamination.

Protection from stored-product insects includes the purchase of insect free products, clean storage conditions, use of insect proof containers, short periods in storage, cold storage, frequent, careful inspections, and fumigation.

Inspection at time of purchase to insure the storage of insect free products is of prime importance and infested products should be rejected. Small infestations may lead to a large population within a short period of time. Stocks should be maintained as small as possible, and old stocks used first. Heavily infested stocks should be surveyed.

Sanitation must be carefully observed in places where food is to be stored. Infestations are supported in cracks and crevices, where small quantities of food materials accumulate, until new stocks are brought in. Torn sacks, broken containers or spilled material should be removed promptly. Goods returned to depots for salvage are often infested and must be fumigated before being carried into warehouses to infest clean stocks. Before loading food stuffs into freight cars and trucks, the interior of the vehicles should be inspected for insects.

Warehouses should be kept at a low temperature in winter without freezing perishable goods, since storage pests generally are inactive at temperatures of 50°F. or below. Small infestations may be killed out, or increase prevented by artificial cold storage when available.

Insect proof containers such as sealed cartons, fabric bags, with paper liners or reinforced paper bags will protect flour and other foods from being infested in transit and in temporary storage.

When practicable, all dry foods to be stored should be inspected for possible infestation prior to being taken aboard ship or being stored ashore. If found infested, they should be disinfested ashore by cold storage, if too heavily infested they should be rejected, or destroyed.

Chapter 12

Rodent Control

GENERAL DUTIES AND RESPONSIBILITIES

1. The responsibilities of the Medical Department as concerned with rodent control are set forth in the Manual of the Medical Department. In order that members of the Medical Department may efficiently execute these responsibilities the following material is presented as a guide. It is necessary to know the habits and characteristics of each species of rodent to be able to apply the best methods of control.

Section I.—RODENT SPECIES

2. Rats have lived in association with man for ages. This close and long association has produced several species of rats peculiarly fitted for specialized conditions.

(a) The brown or Norway rat (*Rattus norvegicus*) is a burrowing animal with great gnawing ability. It is found mainly in basements, embankments, on lower floors of buildings and the hold or lower decks of ships. The body is generally heavy with short ears, heavy tail shorter than body and big feet. They prefer meat, fish, or flesh mixed with a diet of grains, vegetables and fruit.

(b) The gray or roof rat (*Rattus rattus alexandrinus*) is a good climber and may be found living in trees, vines, lofts of buildings and in overhead wiring and upper decks of ships. The body is generally elongated, with long ears. The tail is thin, longer than the body and the feet are slender, fitted for climbing. There are many variations in color and body types. Its food preference varies with its surroundings, but usually fruits and vegetables are well accepted.

(c) The black rat (*Rattus rattus rattus*) is a specialized type of roof, ship or tree rat, it is a good climber and is fre-

quently found aboard ship. This species prefers seeds, cereals, vegetables, fruits and grass but may subsist on leather goods, chocolate bars or weaker members of their own tribe.

(d) Polynesian or Exulans rats are a diminutive species of tree or grass rats. Burrowing in banks or mounds of soil, they infest pineapple fields in the Hawaiian Islands. They are primarily field rodents but will invade housing areas. Their food preference includes cereals, fruits and vegetables.

(e) In the heavily wooded sections of the larger island areas of the western Pacific Ocean area, several types of medium to large tree or wood rats are prevalent. They are generally spiny-furred and do not live in close association with man. They are of no importance from a control standpoint except where military camps are set up inside forested areas.

3. Ground squirrels, field mice, pocket gophers and other field rodents are usually easily controlled by the use of traps, cleaning up and control of natural vegetation, and poison bait.

Section II-A.—CONTROL

4. Rat control programs on naval stations and aboard ship should contemplate rat-proofing of buildings and ships, elimination of food and shelter, and active destruction by trapping, poisoning and, if necessary, fumigation.

5. Ratproofing.-- Existing buildings and new construction should be provided with all necessary safeguards to exclude rats. Such openings as ventilators, gratings or windows should be covered with 28 gauge, 3/8 inch mesh galvanized hardware cloth. Openings around wire leads, pipes, or ventilator shafts should be closed with sheet metal flashing. Conduits for electrical wires, antennae or plumbing should be limited in size so as to have no free space for rodent passage. Cut-offs or fire stops in walls and under floors should be impervious to rats. Doors should be self-closing, tight fitting and provided with metal flashing along the base to prevent access of rats to buildings, or to locate natural harborage, should they inadvertantly gain entrance. Walls should be of solid construction and foundations should extent at least 3 feet below the surface of the ground. Frequent inspection should be made to prevent deterioration of ratproofing measures.

6. Elimination of Food and Shelter.-- Proper handling of food and prompt disposal of garbage to keep food from being available to rats is important in rat-control programs. Food storage structures should be completely rat proofed. Garbage should be placed in tightly covered cans and garbage storage platforms should be elevated at least 3 feet above ground, com-

pletely enclosed and rat proof. Surroundings should be carefully policed and garbage removed frequently. No open garbage dump should be tolerated.

7. Destruction of Rats

(a) Trapping.-- Trapping requires considerable skill, ingenuity and labor to be effective. Large numbers of traps should be used. Baits, when used, should be large and tied securely to the trigger pan. Baits may be any food that rats seem to prefer such as meat, fish, vegetables, peanut butter or bread crust. The ordinary wood spring trap (Catalog of Navy Material, Stock No. 42-T-12900) is probably the most effective and they should be tied to overhead pipes, beams or wires, nailed to rafters or otherwise secured where black greasy marks indicate runways. They should be set at right angles to the runways with trigger pans toward the bulkhead, as rats run close to walls and bulkheads. Boxes and crates should be moved and passageways created where rats cannot pass without going over the traps. In such cases the traps need not be baited, but the trigger pan of the trap should be enlarged with a piece of corrugated paper, cardboard or lightweight sheet metal in order that there will be a larger area for the rat to step on and set off the trap. To guard against the rat jumping over a trap, several traps should be set closely together and then moved each night so that the rats will not become familiar with their location. Rats stay where they feel they are safe; behind boxes, crates, sacks, in crevices between rows and in other hidden places. These and overhead runways are the spots to set the traps. Properly placed traps in a room or compartment should not be visible from the entrance, but should be behind boxes, crates and other objects where the rats stay. Following poisoning it is good practice to use a large number of traps to pick up rodents that missed or refused to take poison baits. "Blanket" coverage of an area with traps should be continued for a 5- to 7-day period. Follow-up trapping may be done on a "spot" trapping basis with a few well-placed traps to pick up the "wise" ones. All traps should be carefully baited and tended daily.

(b) Poisoning.-- When trapping fails to kill all rodents on the ship or station, poisoning should be planned. Red squill can be used with greater safety than other rat poisons but sometimes fails to eradicate the rodents. Whatever poison is chosen, careful preparation, planning and supervision can accomplish very good results. Poisoning should be done with authority of the commanding officer and cooperation of the first lieutenant, maintainance or public works officer, supply officer and medical officer with supervision of the program by the cognizant rodent

control officer. Details of poisoning and preparation of baits are covered in section 3 of this chapter.

(c) Fumigation.-- When neither trapping nor poisoning will accomplish the desired results fumigation should be used. Usually fumigation is not required and should not be necessary except in the case of ships visiting plague infected ports. Fumigation with hydrocyanic acid gas by naval personnel is not permitted but may be done by the United States Public Health Service upon request. Carboxide gas may be used as a fumigant by Navy crews for controlling rats aboard ship at ports not served by the Public Health Service, (Guam, Canal Zone). Calcium cyanide may be used by specially trained crews for controlling rodents in burrows, caves, or other outdoor situations.

Section II-B.--SHIPBOARD AND SHIP-SHORE CONTROL

8. Control of rodents on ships of the Navy is of particular importance in preventing the spread of bubonic plague, which is endemic in many ports of the Far East. Other diseases which may be carried from port to port by the seafaring rat include endemic typhus (flea borne), rat-bite fever and epidemic jaundice (Weil's disease). The same principles of control apply, that is, ratproofing, starving-out and killing but of special importance is that part of ratproofing which prevents rats from boarding ship, or, once aboard from leaving it.

9. Preventing Rodents from Boarding Ships.

(a) Rodents gain access to ships over shore lines, gangways, cargo nets, electric and water lines, and in palletized cargo which has been undisturbed for a period of 30 days or more. Close inspection of cargo is the only practical method of protecting ships against rodents gaining entrance in cargo. Regulations of the port health authority and the port director as to the use of rat guards must be complied with. The following will serve as sample regulations:

(1) Rat guards will be maintained at all times on all lines connecting ships with docks and will be placed in such a manner as to prevent rats from traveling from line to line.

(2) Bow, stern and spring lines will be illuminated between the hours of sunset and sunrise.

(3) All landing ramps and gangways not in use will be removed and all those in use will be illuminated between the hours of sunset and sunrise.

(4) All cargo nets will be lifted aboard ship during hours when cargo is not being transferred at night.

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(b) Some common errors in placing rat guards are:

(1) Guard with central hole not completely filled by lines: Many guards have the central hole too large. If the space is large enough to admit a man's thumb it is large enough for a rat to pass. If several lines are enclosed by one guard, they should be lashed together and any free space stuffed with cloth.

(2) Guard spread at the seams: This happens most often when a guard with too small a central opening is placed around several lines.

(3) Guard too small or sagging: Rat guards should be not less than 3 feet in diameter. Standard guards so placed as to sag have the effect of a smaller guard.

(4) Guard too near dock: Guards are sometimes placed so close to the docks that rats could jump without difficulty from the dock to the rat guard or to the line beyond the guard.

(5) Guards by-passed by crossing lines: Occasionally the lines of different ships are crossed so that guards can be by-passed, i.e., guards on one line are close to the ship; on another, close to the dock.

(6) Guard tied with line over rim: A rat is more likely to climb a tie line to the edge of a guard than it is to jump over the guard.

10. Rat Proofing of Ships

(a) The term "rat-proofing" as applied to vessels may be defined as the process of preventing rats, by mechanical means, from gaining access to and using enclosed spaces for the purpose of hiding, nesting, and breeding, and of depriving them of the opportunity to obtain an adequate food supply by protecting the compartments where food is stored. A rat proof ship, therefore may be considered to be one on which it is so difficult for rats to hide, nest, or gain access to food as to greatly curtail their existence and propagation to a point of ultimate disappearance on board. The aim is to eliminate the principal biological necessities; a protected home and nest in which to shelter and rear the helpless young, and an available food supply, in the absence of which successful propagation is impossible. Rats may enter a ratproof ship just as they may enter a ratproof building; but once on such a ship it will be impossible or difficult for them to hide, except in cargo or stores, which will provide only a temporary shelter. They will be unable to travel from one compartment to another in search of food. They are confronted with an acute housing problem and no means of getting between home and business (food procurement). Under these conditions they will even kill each other in competition for the necessities of life, or

die of hunger or thirst. They will be caught or destroyed more easily in the absence of protection and will breed slowly so that instead of increasing they will actually decrease in numbers.

(b) Provision store rooms should be made rodent proof by closing all openings around pipes, conduits, etc., with metal sheathing, by screening ventilator openings and by keeping hatches and doors shut when not in use. Restorage every 30 days will do much to prevent rats from living and breeding in stocks of provisions. Edible materials in broached containers or torn sacks should be transferred to rat proof containers. Galleys, messhalls and living spaces must be kept clear of food scraps and edible wastes. Garbage must be kept in ratproof G. I. cans. The crew must be indoctrinated with the knowledge that food stowed in lockers will in all probability be shared with the rodent population of the ship unless it is kept in metal containers.

11. Killing Rats On Board.- Once rats get on board trapping is the preferred method of destroying them. If trapping is unsuccessful poisoning should be conducted under the guidance of the fleet or force rodent control officer. Fumigation may be required if five or more rats are on board and the ship has visited a plague port. If required, fumigation may be requested from the United States Public Health Service or fumigation with carhoxide gas may be carried out in accordance with chapter 36 of the Bureau of Ships Manual when the facilities of the United States Public Health Service are not available.

Section III.--POISON BAIT

12. For best results with poisons a complete program of preparation should be included in any application of poison bait as described in the following paragraphs:

13. Check-up Baiting or Test Baiting.

(a) This should be the first step in a baiting program. Its purpose is to learn which foods are most tempting to the rats, where they prefer to take these foods, how many feed at each location and how much bait and poison will be required. Cereals, meats, fish or fats, fruits and vegetables may be used in any combination for bait materials. Rolled oats mixed with meat, fish, fats, or salad oils, or with fruits or vegetables, is most frequently the cereal of choice in any type of bait. Test baits should be selected with consideration of the rodent species and its feeding habits in the area concerned. Freshly prepared bait is important as rats will reject stale or spoiled food.

(b) Prebaiting.--After determining the baits most likely to be taken, prebaits are made up with the most acceptable materials and mixed exactly as poisoned bait but without including the

poison. These baits are exposed for a period of 5 to 7 days and must be observed daily, replacing with fresh bait as necessary. At the end of this period all uneaten prebaits are picked up and destroyed and poison bait is immediately exposed in the same places where prebait was used.

14. Poisoning.

(a) Every precaution should be taken to prepare the poison bait exactly the same as the prebait but with the addition of the poison. The poison bait should be distributed over the area covered with prebait and exposed for a period of 3 days. Baited places should be visited daily and consumed bait replaced with fresh poison bait. At the end of the three-day period all uneaten poison bait should be picked up and burned. A large number of traps should be set to catch any survivors and to determine the degree of extermination accomplished. If it is necessary to repeat the operation, it should be carried out in the same manner using a different poison, and, if test baiting so indicates, another base. Prebaiting and poisoning should be done during periods of clear, calm weather whenever practicable. Unsettled weather interferes with the normal movements and habits of rodents. At least 60 days should elapse between follow-up poison treatments of the same area.

(b) Methods of Exposing Prebaits and Poison Baits.-- The use of feeder stations consisting of a feeder dish and a feeder station cover is the best means of exposing baits. The feeder dish can be made of paper, metal or glass, 1 inch high and 2 or 3 inches in diameter, large enough to hold 1 to 2 ounces of bait. The feeder station cover can be made out of metal, wood cardboard or heavy composition roofing, cut to make an inverted V-shaped cover about 12 inches long, 6 inches wide and 5 inches high. A piece of tin cut in 12 by 12 inch square pieces, "creased" in the middle and bent to form an inverted V makes a good feeder station cover. Feeder stations should be distributed in checkerboard fashion at 100 foot intervals to completely "blanket" any area to be treated, but considerable variation will be necessary to locate each station in hidden places where rats will feed. It is well to number the stations and plot them on a map so that none will be missed or lost. After feeding stations are distributed, clean freshly prepared bait is placed in the feeder dishes, and the supply is replenished daily during test baiting and prebaiting to keep the feeder dishes filled with clean fresh bait. It may require some time before the rats will overcome their natural suspicion and enter the feeding stations. At the end of the prebaiting period all prebait is taken up and burned. Freshly prepared poison bait is immediately placed in feeder dishes and they are kept refilled for a 3 day period, at the end

of which all poison bait is collected and burned. Feeder dishes and station covers are picked up and stored for future use.

(c) Torpedo type baits can be made by wrapping bait materials in paper to make small round baits not more than an inch in diameter. These baits can be tossed on the floors of storerooms, along walls and in corners where they are readily taken by rats. Since rats can carry them away, and children, pets or irresponsible people may find them, they should be used with caution and should usually contain no poison other than red squill. An ounce of poison bait should make six to eight torpedo baits.

15. Bait Formulas

(a) Special types of bait for adverse climatic and natural conditions are listed. For temperate or cold areas it may be practical to use fresh meats or other fresh materials in combination with cereals and oils. Chopped, mixed-vegetables, raw or cooked hamburger or sausage, cracker crumbs, or breakfast foods may prove tempting.

(b) Oil Cereal Baits.-- Oatmeal, corn meal or cereal mixtures should be used at the rate of 100 pounds of bait material to one gallon of oil. Corn oil, cottonseed oil, cocoanut oil and mineral oil, is the recommended order of preference for use. Mineral oil is less acceptable than the edible oils, but does not become rancid as soon. Cocoanut oil is very acceptable when fresh but becomes rancid under normal storage conditions. Ground cocoanut or copra may be used to replace about a fifth of the cereal with the addition of a quart or 2 quarts of cocoanut oil as needed.

(c) Oil-Peanut Butter Cereal baits.-- Peanut butter at the rate of one can (8 pounds) to 3 quarts of oil may be mixed and blended with 100 pounds of cereal bait mixtures. Consistency of oil-peanut butter mixture is such that it requires thorough kneading and mixing to get an even coating of the bait particles. The addition of peanut butter to bait makes for variety or change in make-up of oil-type baits and tends to increase the acceptability of the bait.

(d) Oil-Fish Cereal Baits.-- Canned salmon, tuna fish or mackerel should be broken into finely divided particles and added to vegetable or mineral oil at the rate of 4 to 6 pounds of any one variety of fish to each gallon of oil and 100 pounds of cereal bait materials. This type of bait will not keep in storage and must be used immediately.

(e) Preparation of Baits.-- In preparing any type of oil-cereal baits, the poison should be blended with the oil or sifted slowly and evenly over the bait material after the oil has been added. Thorough mixing of all components is necessary to assure an even distribution of the rodenticide throughout the bait.

16. Rodenticides.

(a) Thallium (thallous) sulphate.-- (Catalog for Navy Material, Stock No. 51-T-4511) is a dense white powder, tasteless and odorless. It should be handled with rubber gloves as it has a cumulative action and is absorbable through the skin. It is used at the rate of 1.5 to 2 percent in all oil cereal type bait. Bulky or coarse type materials require slightly more poison.

(b) Zinc phosphide.-- (Catalog of Navy Material, Stock No. 51-Z-590) is a finely ground black powderlike material and has a distinctive garlic like odor. It should be used at the rate of 1.5 to 2 percent in all oil-cereal type bait. Use the larger amount with bulky coarse bait material. Zinc phosphide should be used in dry weather for best results.

(c) Sodium monofluoracetate (1080).-- (Catalog of Navy Material Stock No. 51-S-3339) is a lightweight white powder. Due to its hygroscopic qualities it should be mixed with oil and then combined with bait materials. It should be used at the rate of 4 ounces to each 100 pounds of cereal type bait materials. One-half ounce of 1080 to 1 gallon of water makes a good poison water solution for use in shallow dishes for controlling rats and mice in warehouses, buildings and aboard ship. Sodium monofluoracetate is very poisonous to man and secondary poisoning which may result when dogs or cats catch poisoned rodents must be carefully avoided. This rodenticide has no known antidote and should be used only in accordance with current instructions of the Bureau of Medicine and Surgery which reserves the quthority to deny issue of this material to commands where a qualified rodent control officer is not available.

(d) Red Squill, Fortified.-- (Catalog of Navy Material, Stock No. 51-S-4840) is a reddish brown powder with a slight acrid odor. It should be used at the rate of 10 pounds to each hundred pounds of cereal type bait materials. It is necessary to use 2 to 4 additional quarts of oil in preparing baits with red squill in order to get an even distribution of the poison. Due to its low toxicity this bait is not recommended for use on naval areas except where children or domestic pets are present or special precautions must be taken in order to protect native laborers.

(e) Others.-- Aresenicals are not recommended for use as rodenticides. Strychnine can be used to control house mice, but other rodenticides listed except red squill will serve the purpose. "Antu" is very effective against the Norway or brown rat but is not recommended for control of the climbing rats

Syrups, sugars or water base spreaders spoil quickly in warm or wet weather and if prepared should be used at once.

If oil-cereal baits are not to be used immediately after preparation they should be put up in air tight dust proof packages and kept in a cool dry storage space.

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